FACT SHEET FOR NPDES PERMIT NO. WA-000367-1

AGRIUM

(formerly Prodica and Unocal)

Kennewick Area Fertilizer Plant

SUMMARY

The Kennewick area fertilizer plant is owned by Agrium. There are three different facilities owned by Agrium all located in the same general area discharging to the Columbia River: the Kennewick area, Finley area, and Hedges area. This fact sheet and the accompanying permit are only concerned with the Kennewick area discharge, located on Bowles Road. The last fact sheet and permit were issued in 1994 and were primarily concerned with temperature and ammonia discharges. The plant manufactures ammonium nitrate as a product and nitric acid used in the production process. The plant discharges up to 40 million gallons per day (mgd) of mostly non-contact cooling water withdrawing and discharging in nearly the same location. This fact sheet goes into detail on the modeling used to determine dilution factors for compliance with State Water Quality Standards.

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INTRODUCTION

The Federal Clean Water Act (FCWA, 1972, and later modifications, 1977, 1981, and 1987) established water quality goals for the navigable (surface) waters of the United States. One of the mechanisms for achieving the goals of the Clean Water Act is the National Pollutant Discharge Elimination System of permits (NPDES permits), which is administered by the Environmental Protection Agency (EPA). The EPA has delegated responsibility to administer the NPDES permit program to the State of Washington on the basis of Chapter 90.48 RCW which defines the Department of Ecology's authority and obligations in administering the wastewater discharge permit program.

The regulations adopted by the State include procedures for issuing permits (Chapter 173-220 WAC), water quality criteria for surface and ground waters (Chapters 173-201A and 200 WAC), and sediment management standards (Chapter 173-204 WAC). These regulations require that a permit be issued before discharge of wastewater to waters of the state is allowed. The regulations also establish the basis for effluent limitations and other requirements which are to be included in the permit. One of the requirements (WAC 173-220-060) for issuing a permit under the NPDES permit program is the preparation of a draft permit and an accompanying fact sheet. Public notice of the availability of the draft permit is required at least thirty days before the permit is issued (WAC 173-220-050). The fact sheet and draft permit are available for review (see Appendix A--Public Involvement of the fact sheet for more detail on the Public Notice procedures).

The fact sheet and draft permit have been reviewed by the Permittee. Errors and omissions identified in this review have been corrected before going to public notice. After the public comment period has closed, the Department will summarize the substantive comments and the response to each comment. The summary and response to comments will become part of the file on the permit and parties submitting comments will receive a copy of the Department's response.

The fact sheet has been revised to correct minor errors and to improve clarity. Comments and the resultant changes to the permit will be summarized in Appendix F--Response to Comments.

GENERAL INFORMATION	
Applicant	Agrium, LLC (Prodica, Unocal Petroleum Products)
Facility Name and Address	Kennewick Area Plant (Bowles Road) P.O. Box 5797 Kennewick, WA 99336
Type of Facility:	Fertilizer Manufacturing (Ammonium Nitrate, Urea Ammonium Nitrate, Calcium Ammonia Nitrate, and Nitric Acid)
SIC Code	2873 Nitrogenous Fertilizers
Discharge Location	Waterbody name: **Columbia River, at River Mile 322.6;** Latitude: 46° 10' 00" N Longitude: 119° 00' 43" W
Water Body ID Number	26-00-02

BACKGROUND INFORMATION

DESCRIPTION OF THE RECEIVING WATER

The discharge outfall is located in the Columbia River approximately two miles downstream of the confluence with the Snake River. The discharge site is at river mile 322.6. A location map of the site and discharge can be found in Appendix D. The Columbia River at this location has a regulated flow; the minimum and maximum flows are generally evened out by the dams. The river at this point is approximately 7680 feet wide, however, Foundation Island splits the river approximately 3,940 feet from the west shore where the plant and outfall reside. The depth of the western channel is about 45 feet deep and the eastern channel is 5 to 10 feet deep. Approximately 88 percent of the river flow goes through the channel west of Foundation Island.

The upstream dam at Priest Rapids on the Columbia River, Ice Harbor dam on the Snake River, and the downstream dam at McNary on the Columbia River regulate the stage height and discharge rate of the river. The regulated *minimum* discharge for the Columbia River at this site as stated in the 1994 fact sheet is 44,000 cfs. More detail on minimum flows based on statistical records may be found later in this report. Based on this minimum flow, the current velocity used for modeling was 0.37 ft/sec. The maximum discharge for the Columbia River at this site is approximately 383,843 cfs; the maximum velocity used was about ten times the minimum at 3.7 ft/sec. The average velocity used was 1.5 ft/sec.

DESCRIPTION OF THE FACILITY

History

A complete history may be found in the 1994 permit fact sheet. Since 1994 the facility has increased efficiency and production in the nitric acid plants, which has resulted in an increase of water discharged to the Columbia River. The company also began producing calcium ammonium nitrate--17% nitrogen (CAN-17).

Industrial Process

The Agrium (Unocal) facility was originally constructed in the 1950s. There are three facilities in this area: the Kennewick Area, Finley Area, and Hedges Area. All three facilities are currently owned by Agrium and produce products for manufacturing fertilizer. The facility was previously owned by Phillips Petroleum; Chevron Corporation; Union Oil Company of California (Unocal) Petroleum Products & Chemicals Division, Agricultural Products Group; and was most recently operated under the name Prodica, LLC. During the last six months the plant changed its name and ownership from Prodica to Agrium. The plant also increased production over the last permit cycle. The products produced at the plant include liquid and dry Ammonium Nitrate, Urea Ammonium Nitrate, Calcium Ammonium Nitrate, and Nitric Acid. The following table shows the sub-plants that are producing each product, the flow of water required (mostly non-contact cooling water), the tons of product produced and the totals produced. The plant operates 24 hours per day.

Table 1: Average Daily Production and flow at the Kennewick Plant

PRODUCTION UNIT	Flow	Tons/day	Total
Nitric Acid Plants #2 & 7	2(5615)=11,230 gpm	450 tons/day	1200 tons/day
Nitric Acid Plant #9	12,250 gpm	750 tons/day	
Ammonium Nitrate Plant #3	426 gpm	320 tons/day	1550 tons/day
Ammonium Nitrate Plant #10	8 gpm	550 tons/day	
Ammonium Nitrate 20% N Plant	24 gpm	180 tons/day	
*Calcium Ammonium Nitrate – 17%	71 gpm	500 tons/day	
Urea Ammonium Nitrate-32 Plant # 8 & 11	182 gpm	1,950 tons/day	1,950 tons/day
Utilities	617 gpm	NA	
Ammonia Refrigeration	214 gpm	NA	
Demineralization Regeneration	50,000 gpd = 35 gpm	NA	
Total	25,058 gpm = 36.08 mgd		

*Calcium Ammonium Nitrate –17 production started in 1996.

The water used for non-contact cooling does not pass through any kind of treatment or cooling tower before being discharged to the Columbia River. Even though the cooling water is mostly non-contact, there is a certain amount of ammonia and nitrate that is discharged with contact cooling water. During the last permit cycle, the Permittee instituted efficiency improvements in the nitric acid plant operation. These changes resulted in increased water inflow for non-contact cooling and a corresponding increase in the wastewater discharge. Projected average under the last permit was to increase from 23 mgd to 36.4 mgd and a maximum of 40 mgd. As noted above, the average flow is now 36.08 mgd. The existing limit of the plant's water rights is 40 mgd.

Approximately 94 percent of the water supplied to the plant is used as once through non-contact cooling water. The balance of the water is used in the plant or becomes contact return flow. The contact water includes refrigeration condensate, and process water discharges from each of the separate plants. The contact water is collected in a contact return gravity sewer and a continuous sampling point (Manhole 7) is setup prior to the flow mixing with the non-contact cooling water (Manhole 8). A schematic diagram of water system flows for the Kennewick area may be found in Appendix E.

The plant water supply system consists of a multi-port intake structure in the Columbia River, and wells. The water volume supplied by the wells averages 2,365 gpm while the river intake supplies the balance at and average of 22,693 gpm. The intake structure consists of a 200-foot long, 30-inch steel pipe, with a 60-foot pile-supported intake pipe section. The intake header line consists of 9 30-inch intake ports each with a 4-foot long screen cylinder.

Discharge Outfall

Wastewater from the Kennewick Area is discharged continuously through a submerged, multi-port outfall diffuser into the Columbia River at River Mile 322.6. The discharge is located offshore of the west river bank, approximately 2 miles downstream from the confluence of the Snake River with the Columbia. The 42-inch steel outfall pipe extends approximately 374 feet from the river shore to the start of the diffuser. The 172-foot long outfall diffuser section lies on the river bed, and stretches from 375 to 525 feet from the river shore. The multi-port diffuser consists of 44 6-inch diameter ports spaced 4.0 feet apart, all of which discharge horizontally downstream. The water depth at the diffuser ports averages approximately 21 feet at normal pool elevation (340.0 ft NGVD). In the review of this permit, the Permittee determined that their outfall was situated with a 15° angle downstream from perpendicular to the flow (off from 90° or 105° total). This "hang" angle affected the outcome of dilution modeling. The angled diffuser provides more dilution in some cases and less dilution in others. The recalculated dilution factors and analysis are shown in Table 7 and Appendix C.

PERMIT STATUS

The previous permit for this facility was issued on **August 25, 1994**.

Table 2: Previous permit limits

Parameter	Average Monthly	Maximum Daily
Flow	36.4 mgd	40.0 mgd
pH	In the range of 6.0 – 9.0	
Temperature		Maximum 38.3°C at 19 mgd or less 34.3°C at 19 – 28 mgd 32.5°C at 28 – 40 mgd
Ammonia	108 lbs/day	341 lbs/day
Nitrate	206.7 lbs/day	610.3 lbs/day

These limitations from the original permit also had footnotes that defined and added to the limits. The full footnotes may be found in the original 1994 permit. It is important to note that pH was further limited when:

1) The total time during which the pH values are outside the required range of pH values shall not exceed 4 hours in any calendar month.

2) No individual excursion from the range of pH values shall exceed 30 minutes.

Temperature was also further limited when: temperature in the river shall not exceed 20.0°C due to human activities; and when natural river conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C at the boundary of the discharge mixing zone. Nor shall temperature increases at any time exceed $t=34/(T+9)$, where T is the background temperature and t is the net temperature increase due to the discharge. This last part applies when background temperature is at or below 20.0°C

An application for permit renewal was submitted to the Department and accepted on **January 27, 1999**.

SUMMARY OF COMPLIANCE WITH THE PREVIOUS PERMIT

The facility last received a compliance inspection on **August 23, 2000**. No samples were taken at that time.

During the history of the previous permit, the Permittee has remained in compliance based on Discharge Monitoring Reports (DMRs) submitted to the Department and inspections conducted by the Department. The exceptions have been for pH exceedances above 9.0 for very short durations. There were eight pH exceedances noted over the period of January 1998 through February 2000. None of the pH excursions exceeded 30 minutes in any one calendar month.

Temperature, nitrates, and ammonia have all been well within the limits set by the 1994 permit. The maximum ammonia level noted was 140 lbs/day with the rest of the values below 43 lbs/day. However, even with the ammonia and nitrate concentrations and loads well within limits, some whole effluent toxicity tests indicated potential toxicity, likely due to ammonia. Whole effluent toxicity will be discussed later in this report.

The Department of Ecology regularly receives requests from the Permittee to discharge neutralized 10% HCl cleaning solution used to clean the plant heat exchanger units during periodic turn-arounds or maintenance shutdowns. The Department has also received requests to discharge approximately 6000 gallons of fluid used as compressor coolant, which may contain corrosion inhibitor (sodium hydroxide, sodium nitrate, and sodium molybdate). In the 1994 fact sheet the company stated that the acid cleaning solution would be neutralized to a pH of 6.5 to 7.5 before being discharged at a maximum rate of 35 gallons per minute, with a total discharge volume not to exceed 2,000 gallons. No analysis has been conducted on these discharges to date. Testing to characterize these discharges will be required during the next permit cycle under section S8 of the permit.

Investigations of ground water conditions prior to 1991 found groundwater plumes containing above normal nitrate and ammonia nitrogen concentrations. A groundwater remediation project began in 1991 to pump water from wells and then irrigate croplands, providing water and nitrogen-based nutrients to crops. A state discharge permit (ST-9164) for land application was issued to Unocal. The remediation was expected to be completed in about seven years. The project was still continuing during the last inspection in August, 2000. The state discharge permit is still in effect.

WASTEWATER CHARACTERIZATION

The proposed wastewater discharge is characterized for the following regulated parameters:

Table 3: Wastewater Characterization (from DMRs 1/98-2/00)

Parameter	Average Observed	Maximum Observed	Average Permit Limit	Maximum Permit Limit
Flow (mgd)	25.2	33.3	36.4	40
pH (lower avg – upper avg)	7.3 – 8.9	6.4 – 10.1	NA	6.0 – 9.0
Temperature (°C)	24.6	32.6	NA	See Table 2 for limits
Ammonia (lbs/day)	9.4	140	108	341.6
Nitrate (lbs/day)	12.6	255	206.7	610.3

The effluent appears to be have been well within permit limits for most of the parameters as shown in table 3 above.

SEPA COMPLIANCE

No changes in construction or water consumption or other environmental change have triggered the State Environmental Policy Act (SEPA).

PROPOSED PERMIT LIMITATIONS

Federal and State regulations require that effluent limitations set forth in a NPDES permit must be either technology- or water quality-based. Technology-based limitations are based upon the treatment methods available to treat specific pollutants. Technology-based limitations are set by regulation or developed on a case-by-case basis (40 CFR 125.3, and Chapter 173-220 WAC). Water quality-based limitations are based upon compliance with the Surface Water Quality Standards (Chapter 173-201A WAC), Ground Water Standards (Chapter 173-200 WAC), Sediment Quality Standards (Chapter 173-204 WAC) or the National Toxics Rule (Federal Register, Volume 57, No. 246, Tuesday, December 22, 1992). The more stringent of these two limits must be chosen for each of the parameters of concern. Each of these types of limits is described in more detail below.

The limits in this permit are based in part on information received in the application and discharge monitoring reports (DMRs). The effluent constituents in the application were evaluated on a technology and water quality-basis. The limits necessary to meet the rules and regulations of the State of Washington were determined and included in this permit. Ecology does not develop effluent limits for all pollutants that may be reported on the application as present in the effluent**.** Some pollutants are not treatable at the concentrations reported, are not controllable at the source, are not listed in regulation, and do not have a reasonable potential to

cause a water quality violation**.** Effluent limits are not always developed for pollutants that may be in the discharge but not reported as present in the application. In those circumstances the permit does not authorize discharge of the non-reported pollutants. Effluent discharge conditions may change from the conditions reported in the permit application. If significant changes occur in any constituent, as described in 40 CFR 122.42(a), the Permittee is required to notify the Department of Ecology. The Permittee may be in violation of the permit until the permit is modified to reflect additional discharge of pollutants.

TECHNOLOGY-BASED EFFLUENT LIMITATIONS

The appropriate technology-based effluent limitation guidelines are located in 40 CFR 418, subpart D – Ammonium Nitrate Subcategory and in 40 CFR 418, Subpart E – Nitric Acid Subcategory. The 1994 permit limits were based in part on these regulations.

The average production for each portion of the Kennewick Area plant is:

PRODUCTION UNIT	**FLOW**	**TONS/DAY**	**TOTAL**
Nitric Acid Plants #2 & 7	2(5615)=11,230 gpm	450 tons/day	1,200 tons/day
Nitric Acid Plant #9	12,250 gpm	750 tons/day	
Ammonium Nitrate Plant #3	426 gpm	320 tons/day	1,550 tons/day
Ammonium Nitrate Plant #10	8 gpm	550 tons/day	
Ammonium Nitrate 20% N Plant	24 gpm	180 tons/day	
*Calcium Ammonium Nitrate – 17%	71 gpm	500 tons/day	
Urea Ammonium Nitrate-32 Plant # 8 & 11	182 gpm	1,950 tons/day	1,950 tons/day
Utilities	617 gpm	NA	
Ammonia Refrigeration	214 gpm	NA	
Demineralization Regeneration	35 gpm	NA	

*Calcium Ammonium Nitrate –17 production started in 1996.

The total ammonium nitrate production including the calcium ammonium nitrate and urea ammonium nitrate is 1,550 + 1,950 tons/day = 3,500 tons/day

Federal regulation in 40 CFR 418 subparts D and E provide limits on how much product an industry that produces ammonium nitrate and nitric acid may discharge. The discharge limitations for Nitric Acid portion of the plant from 40 CFR 418.53(b) are:

Parameter	Federal Nitric Acid Effluent limitation Standards (lb/1000 lbs of product)	
	Max for any one day	Average of daily values for 30 consecutive days not to exceed
Ammonia (as N)	0.08	0.008
Nitrate (as N)	0.17	0.023

The total nitric acid production is 1,200 tons/day. Therefore, the limits based on standards for performance under the federal regulation for the nitric acid production are:

Parameter	Effluent limits for Kennewick Area Nitric Acid	
	Daily Maximum	Monthly Average
Ammonia (as N)	1,200 x 0.08 x 2 = 192 lbs./day	1,200 x 0.008 x 2 = 49.2 lbs/day
Nitrate (as N)	1,200 x 0.17 x 2 = 408 lbs/day	1,200 x 0.023 x 2 = 55.2 lbs/day

Effluent limitations for the production of Ammonium Nitrate from 40 CFR 418.43 are:

Parameter	Federal Ammonium Nitrate Effluent limitation Standards (lb/1000 lbs of product)	
	Max for any one day	Average of daily values for 30 consecutive days not to exceed
Ammonia (as N)	0.08	0.04
Nitrate (as N)	0.12	0.07

The total ammonium nitrate produced at the Kennewick Area plants as stated above is 3,500 lbs/day. Therefore, the limits based on standards for performance under the federal regulation for the ammonium nitrate production at this portion of the plant are:

Parameter	Effluent limits for Kennewick Area for Ammonium Nitrate	
	Daily Maximum	Monthly Average
Ammonia (as N)	3,500 x 0.08 x 2 = 416 lbs/day	3,500 x 0.04 x 2 = 280 lbs/day
Nitrate (as N)	3,500 x 0.12 x 2 = 840 lbs/day	3,500 x 0.07 x 2 = 490 lbs/day

The Kennewick area plants have only one discharge. The total limits on ammonia and nitrate based on the federal regulations is:

Total Technology Based Discharge

Parameter	Total Effluent limits	
	Daily Maximum	Monthly Average
Ammonia (as N)	192+416= 752 lbs/day	19.2+280= 299.2 lbs/day
Nitrate (as N)	408+840= 1248 lbs/day	55.2+490= 545.2 lbs/day

The limits shown above represent the Best Available Technology (BAT). The applicant has consistently maintained a discharge of pollutants well below the existing limits. Under the 1994 permit and fact sheet the applicant agreed to continue to operate within those limits set in 1994. This represents a level of pollution control in excess of BAT. The ammonia and nitrate limit set in 1994 are protective of water quality and meet BAT. To prevent backsliding on the permit limits, the 1994 limits will be carried over into this permit. Those limits are:

	Average Daily Limit	Average Monthly Limit
Ammonia (as N)	341 lbs/day	108 lbs/day
Nitrate (as N)	610.3 lbs/day	206.7 lbs/day

Table C1 and C2 in Appendix C show the results of toxicity tests with effluent from the Kennewick facility. More will be discussed in this fact sheet under the heading of Whole Effluent Toxicity and under technology and water quality based limits. Because ammonia becomes more toxic with increased temperature and pH, these parameters should be closely monitored over the life of the next permit.

The calculation of reasonable potential for ammonia to exceed water quality standards did not show that a limit was required. These calculations may be found in appendix C in tables C3 and C5.

According to the U.S. Environmental Protection Agency, *Goldbook*, there does not appear to be a nitrate criterion for aquatic life of less than 90 mg/l. There is a Human Health criterion of 10 mg/l. The discharge of nitrate over the period of January 1998 through February 2000 produced a maximum of 255 lbs/day. With the maximum flow of 28.9 mgd during the month that nitrate discharge was recorded the concentration of nitrate would amount to a maximum of 255/(28.9x 8.34) = 1.058 mg/l which is much less than the suggested criteria.

DISCUSSION OF PERFORMANCE BASED LIMITS FOR FUTURE TMDL AND WLA

The average ammonia and nitrate values observed in the effluent over the last two years of data are less than ten percent of those set by the technology based limits discussed above and used in the previous permits. The maximum values observed for these parameters are two to three times less than the permit limits.

If new limits on ammonia and nitrate were to be put in place they should reflect actual performance and yet not be so stringent as to put the plant immediately out of compliance. As a starting point, the maximum levels observed in the last two years of performance could be used. This would allow the plant to stay within compliance during all operations observed over the last two years. Limits for flow, temperature, and pH would potentially remain the same. These potential new limits for nitrogen and ammonia would be as follows:

Table 4A: Potential Performance Based Limits for Ammonia and Nitrate (Option 1, 100th percentile)

PARAMETER	AVE MONTHLY LIMITS	MAXIMUM DAILY LIMITS
Ammonia	22.6 lbs/day	140 lbs/day
Nitrate	52.4 lbs/day	255 lbs/day

(Note: these are the highest values observed over the last two years and are equivalent to the 100th percentile for that period)

A somewhat more rigorous approach would be to use the method recommended by EPA for establishing performance based limits. Table C4 in Appendix C is an Ecology spreadsheet that statistically calculates the 95th percentile for a data set. The spreadsheet is based on EPA guidance. In this particular instance the ammonia data from January through September 2000 was used. The results of this method are shown in table 4B.

Table 4B: Potential Performance Based Limits for Ammonia and Nitrate (Option 2, 95th percentile)

PARAMETER	AVE MONTHLY LIMITS		MAXIMUM DAILY LIMITS	
Ammonia	0.23 mg/L	3.61 lbs/day	0.74 mg/L	11.44 lbs/day
Nitrate	0.30 mg/L	4.55 lbs/day	0.66 mg/L	9.07 lbs/day

(Note: Option 2 is based on a shorter time period (1/00-9/00), but, with more data points than option 1.)

It is possible to see from these two methods that there is a large variance in the ammonia and nitrate released by the Agrium facility. Most notable is that 95 percent of the time the facility does not release more than 11.44 lbs/day of ammonia. On only a couple of occasions during the last two years was there a release of ammonia as high as 140 lbs/day. This indicates that releases of ammonia or nitrate by the facility should be rare, preventable occurrences and the facility should be able to keep the releases of ammonia down below 11.44lbs/day.

These performance based limits are the result of the plant's ability to control pollutants and the application of All Known Available and Reasonable Treatment (AKART) and Best Professional Judgment (BPJ) to make a determination. A performance based limit is not proposed at this time.

SURFACE WATER QUALITY-BASED EFFLUENT LIMITATIONS

In order to protect existing water quality and preserve the designated beneficial uses of Washington's surface waters, WAC 173-201A-060 states that waste discharge permits shall be conditioned such that the discharge will meet established Surface Water Quality Standards. The Washington State Surface Water Quality Standards (Chapter 173-201A WAC) is a state regulation designed to protect the beneficial uses of the surface waters of the state. Surface water quality-based effluent limitations may be based on an individual waste load allocation (WLA) or on a WLA developed during a basin wide total maximum daily loading study (TMDL). However, a TMDL has not been completed for this section of water and may not be completed for several years.

Numerical Criteria for the Protection of Aquatic Life

"Numerical" water quality criteria are numerical values set forth in the State of Washington's Water Quality Standards for Surface Waters (Chapter 173-201A WAC). They specify the levels of pollutants allowed in a receiving water while remaining protective of aquatic life. Numerical criteria set forth in the Water Quality Standards are used along with chemical and physical data for the wastewater and receiving water to derive the effluent limits in the discharge permit. When surface water quality-based limits are more stringent or potentially more stringent than technology-based limitations, they must be used in a permit.

Numerical Criteria for the Protection of Human Health

The U.S. EPA has promulgated 91 numeric water quality criteria for the protection of human health that are applicable to Washington State (EPA 1992). These criteria are designed to protect humans from cancer and other disease and are primarily applicable to fish and shellfish consumption and drinking water from surface waters.

Narrative Criteria

In addition to numerical criteria, "narrative" water quality criteria (WAC 173-201A-030) limit toxic, radioactive, or deleterious material concentrations below those which have the potential to adversely affect characteristic water uses, cause acute or chronic toxicity to biota, impair aesthetic values, or adversely affect human health. Narrative criteria protect the specific beneficial uses of all fresh (WAC 173-201A-130) and marine (WAC 173-201A-140) waters in the State of Washington.

Antidegradation

The State of Washington's Antidegradation Policy requires that discharges into a receiving water shall not further degrade the existing water quality of the water body. In cases where the natural conditions of a receiving water are of lower quality than the criteria assigned, the natural conditions shall constitute the water quality criteria. Similarly, when the natural conditions of a receiving water are of higher quality than the criteria assigned, the natural conditions shall constitute the water quality criteria. More information on the State Antidegradation Policy can be obtained by referring to WAC 173-201A-070.

Critical Conditions

Surface water quality-based limits are derived for the waterbody's critical condition, which represents the receiving water and waste discharge condition with the highest potential for adverse impact on the aquatic biota, human health, and existing or characteristic water body uses.

The critical condition for temperature occurs at maximum effluent discharge (40 mgd), and minimum river flow (44,000 cfs) which results in a chronic dilution factor of 27:1 and an acute dilution factor of 15:1. These dilution factors are the result of computer modeling using UM Plumes (see Appendix C).

The dilution factors resulted from modeling that was based in part on the flow and velocity of the Columbia River at the approximate location of the outfall. The outfall is located downstream of the confluence of the Snake and Columbia Rivers. The Yakima River also adds to the flow at this point. The river is approximately 7680 feet wide at the point of the outfall, however, the river is split by Foundation Island at this point. The width in the western channel where the outfall is located is approximately 3940 feet wide. The western channel averages 30 feet deep and the channel east of Foundation Island is ten or less feet deep. About 88 percent of the River flow goes through the channel west of Foundation Island.

An analysis of the River flow looked at historic records compiled by the USGS (Williams, 1985) for the Columbia River at Priest Rapids, Ice Harbor, and the Yakima River and a minimum resulting from reservoir operation. The low flows were as follows:

Columbia River at Priest Rapids, USGS (18 years of record)	20,960.4 cfs
Snake River at Ice Harbor, USGS (25 years of record)	13,041.1 cfs
Yakima River at Kiona, USGS (71 years of record)	441.4 cfs
Total flow at the Confluence	34,442.9 cfs

This low flow is very close to the flow predicted and used in the 1994 fact sheet of 44,000 cfs. That flow was also based on the premise that the minimum flow is controlled by the Army Corps of Engineers. Therefore a low flow of 44,000 cfs was used in the dilution model. A cross sectional analysis of the River channel was used to determine that the western channel averages 30 ft deep (see river cross section at the end of Appendix C).

3940 ft x 30 ft = 118,200 ft^2

44,000 cfs x 88% = 38,720 cfs, 38,720 cfs/118,200 ft^2 = 0.33 ft/s

Considering that 88 percent of the flow goes through this portion of the river, a velocity of about 0.33 ft/s was calculated. The velocity used in the model was very close to this value at 0.37 ft/s where the value used in the 1994 fact sheet was 0.42 ft/s. However, the value of 0.37 ft/s agrees very well with field measured current velocities observed by consultants and reported in the 1994 fact sheet. A study of the former Chevron outfall was conducted on June 21, 1989 when the river discharge at McNary Dam was 180,000 cfs. Current velocities ranged from 0.64 ft/sec to 1.26 ft/sec. The 1994 fact sheet showed calculations of 0.42 ft/sec (at 44,000 cfs) and 1.72 ft/sec (at 178,000 cfs).

The high flow 90% exceedance values or 7Q90 for the Columbia were predicted as follows:

Columbia River at Priest Rapids, USGS (20 years of record)	289.777.3 cfs
Snake River at Ice Harbor, USGS (69 years of record)	88,731.7 cfs
Yakima River at Kiona, USGS (80 years of record)	5,333.5 cfs
Total at Confluence	383,842.5 cfs

From the flow shown above and cross sectional analysis a velocity of 2.83 ft/s was calculated, however, the Ecology chose to use a value of 3.7 ft/s as the worst case scenario based on velocities used in the previous fact sheet, graphic linear comparisons of values and best professional judgment. A graph showing the range of predicted velocities versus flow is shown at the end of Appendix C.

Results of dilution modeling on temperature

The ambient conditions used in temperature dilution modeling are those observed in the months of July and August of 1998 and 2000. Because the applicant did not sample influent temperature, there was no ambient information for temperatures in the vicinity of the outfall. However, some ambient river information on temperature was found on the Army Corps of Engineer's web-site for dissolved gas and temperature data at: http://www.nwd-wc.usace.army.mil/TMT/tdg_data/months.html#P. The temperature data sites examined at this web-site included Pasco, Ice Harbor tailwater, and McNary Washington fore bay. The Pasco site did not exist before the year 2000; therefore, the Priest Rapids site was used for temperature data for 1998-1999. An energy balance equation was used to determine the contribution of the Snake River to the Columbia River:

$Q_1T_1 + Q_2T_2 = Q_3T_3$ Where Q is flow and T is temperature.

Three scenarios are given for critical temperatures after mixing of the Snake and Columbia. The data used and the results are:

Table 5: Critical Temperature at the Confluence of the Snake R. and Columbia R.

Station	Date	Temp. (°C)	Flow (kcfs)	Predicted Downstream Temp (°C)
Pasco	8/24/00	20.8	77.3	20.8
Ice Hbr tailrace	8/24/00	20.8	17.1	
Pasco	8/2/00	20.0	112.5	20.3
Ice Hbr tailrace	8/2/00	22.0	20.4	
Priest Rapids	8/12/98	21.1	109.4	21.6
Ice Hbr tailrace	8/12/98	22.5	62.9	

The applicant reported temperatures just downstream at the Finley Area intake. Even though the Finley area is downstream and may be influenced by the Kennewick area discharge, the data may be compared to the above predicted values. These temperatures are maximums reported at the intake:

Table 7: Finley area intake temperatures maximums

Jul-00	21.1
Aug-00	20.1
Sep-00	19.0

From these different sources of information it was determined that a maximum ambient temperature used in the 1994 fact sheet and modeling of **21.1°C** was satisfactory for modeling for this new fact sheet.

Ambient ammonia data for the Columbia River was obtained from the Department of Ecology, Environmental Assessment Program's ambient water quality web-site at: http://www.ecy.wa.gov/programs/eap/fw_riv/data/rv33a050.html. The station used to obtain a critical condition was the Snake River near Pasco. A value of .073 mg/L ammonia was obtained for ambient river conditions and used in the reasonable potential determination in Appendix C.

A permit condition has been added requiring the facility to perform a temperature study in the river during critical conditions in the vicinity of the discharge point. This data will allow Ecology to better analyze whether or not the discharge is in conformance with water quality standards for temperature.

Mixing Zones

The Water Quality Standards allow the Department of Ecology to authorize mixing zones around a point of discharge in establishing surface water quality-based effluent limits. Both "acute" and "chronic" mixing zones may be authorized for pollutants that can have a toxic effect on the aquatic environment near the point of discharge. The concentration of pollutants at the boundary of these mixing zones may not exceed the numerical criteria for that type of zone. Mixing zones can only be authorized for discharges that are receiving all known, available, and reasonable methods of prevention, control and treatment (AKART) and in accordance with other mixing zone requirements of WAC 173-201A-100.

The National Toxics Rule (EPA, 1992) allows the chronic mixing zone to be used to meet human health criteria.

Description of the Receiving Water

The facility discharges to the Columbia River which is designated as a Class *A* receiving water in the vicinity of the outfall. Other nearby point source outfalls include those owned by Agrium and others. Agrium has an outfall approximately three fourths of a mile upstream at the Hedges Area plant and another outfall approximately one mile downstream at the Finley Area plant. There are other outfalls for the cities of Kennewick, Pasco, and Richland located upstream more than one half mile away. These other discharges are municipal in nature and have a maximum combined flow of 17.14 mgd. None of the mixing zones from these other outfalls are expected to influence the river outside of the mixing zones or overlap with the Agrium discharge. Significant nearby non-point sources of pollutants include extensive agriculture on the Yakima River which discharges upstream of the Agrium discharge.

Characteristic uses of Class A waters include the following:

> water supply (domestic, industrial, agricultural); stock watering; fish migration; fish rearing, spawning and harvesting; wildlife habitat; primary contact recreation; sport fishing; boating and aesthetic enjoyment; commerce and navigation. Water quality of this class shall meet or exceed the requirements for all or substantially all uses.

Surface Water Quality Criteria

Applicable criteria are defined in Chapter 173-201A WAC for aquatic biota. In addition, U.S. EPA has promulgated human health criteria for toxic pollutants (EPA 1992). Criteria for the Columbia River at this discharge are summarized below:

Criteria for Class A Waters (From WAC 173-201A)

Fecal Coliforms	100 organisms/100 mL maximum geometric mean
Dissolved Oxygen	8 mg/L minimum
Temperature	20 degrees Celsius maximum. When natural conditions exceed 20°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time exceed t=34/(T+9).
PH	6.5 to 8.5 standard units
Turbidity	less than 5 NTU above background
Toxics	No toxics in toxic amounts (see WAC 173-201A for numeric criteria for toxics of concern for this discharge)

The Columbia River has several 303(d) listings for this segment of the river and downstream. Section 303(d) of the federal Clean Water Act requires the State of Washington to list water bodies that do not meet water quality standards and take action to correct those problems. The Columbia River is listed for temperature, and sediments. There are other listings on the Columbia River that probably do not apply (e.g., toxics, arsenic, fecal coliform). The Snake River also has 303(d) listings for temperature and dissolved oxygen.

The Clean Water Act requires the state to follow a 303(d) listing with a study and plan to improve the water body and remove the impaired water from the list. This study and plan is called a Total Maximum Daily Load (TMDL). A TMDL has been proposed for the Columbia but is not completed. During the next permit cycle, loads may be proposed for industry along the Columbia River. At this time there has not been a determination as to what to do with existing loads or even how much they contribute.

Consideration of Surface Water Quality-Based Limits for Numeric Criteria

Pollutant concentrations in the proposed discharge exceed water quality criteria with technology-based controls which the Department has determined to be AKART. The existing permit specifies the allowable pH limits, the maximum allowable temperature increase, and the allowable limits for ammonia and nitrates A mixing zone is authorized in accordance with the geometric configuration, flow restriction, and other restrictions for mixing zones in Chapter 173-201A WAC and is defined as follows:

> The chronic mixing zone shall extend a distance of 321 feet downstream from each of the diffuser ports, and a distance of 100 feet upstream from each of the diffuser ports. The chronic mixing zone shall not use greater than twenty-five percent of the flow or occupy greater than twenty-five percent of the river width. The zone of acute criteria exceedance shall extend a distance of 32 feet downstream and 10 feet upstream from each of the diffuser ports.

The dilution factors (dilution of effluent to receiving water) that occur within these zones have been determined at the critical condition by the use of UM Plumes model. The Plumes model was run 23 times by Ecology with different scenarios of effluent temperature, critical ambient temperature effluent flow, and ambient current speed. The critical conditions used for the model runs are shown in table 7. The model was re-calibrated and run again by CH2MHILL for the Permittee with new information on the angle of the outfall diffuser. The result of the model runs was a higher acute dilution and a lower chronic dilution as shown below.

The dilution modeling was redone for this permit because some of the modeling in the 1994 permit fact sheet was found to have problems. The 1994 model run used flux based dilution instead of centerline dilution. Department of Ecology policy states that flux based dilution should only be used in non-directional waters such as marine waters. Centerline dilution is appropriate for the case at hand: the riverine environment. The UDKHDEN model was also used in the 1994 modeling which is used for discharge plumes that are at right angles to the direction of flow.

However, the UM Plumes is more appropriate to use when the discharge plume is in the same direction as the flow as in the case of the Agrium discharge as stated in the description of the discharge outfall. The dilution factors that resulted from the modeling are:

	Acute	Chronic
Aquatic Life	15	27
Human Health, Carcinogen		27
Human Health, Non-carcinogen		27

Pollutants in an effluent may affect the aquatic environment near the point of discharge (near field) or at a considerable distance from the point of discharge (far field). Toxic pollutants, for example, are near-field pollutants--their adverse effects diminish rapidly with mixing in the receiving water. Conversely, a pollutant such as BOD is a far-field pollutant whose adverse effect occurs away from the discharge even after dilution has occurred. Thus, the method of calculating surface water quality-based effluent limits varies with the point at which the pollutant has its maximum effect.

The derivation of surface water quality-based limits also takes into account the variability of the pollutant concentrations in both the effluent and the receiving water.

Table 7: Critical Conditions and Model Parameters

Parameter	**Value used**
7Q10 flow	44,000 cfs min, 178,000 cfs average, 383,842 cfs high
Velocity	0.37 ft/sec min, 1.52 ft/sec average, 3.7 maximum
Depth of diffuser	21 feet (Ave. Channel depth 30 ft)
Angle of diffuser	105° (directed 15° downstream from perpendicular)
Width	Approx. 3940 ft
Roughness (Manning)	n=0.039
Slope	0.001 ft/ft, (0.057 degrees)
Temperature	21.1^{o} C ambient, 32.2 ^{o} C – 38.3 ^{o} C effluent
pH (high)	8.44 ambient, 9.0 effluent
Dissolved Oxygen	9.0 mg/L
Total Ammonia-N	0.073 mg/L (ambient)
Turbidity	20 NTU
Hardness	50 mg/L as CaCO3

The impacts of dissolved oxygen deficiency, temperature, and pH were determined as shown below, using the dilution factors and critical conditions described above.

BOD_5—This discharge with technology-based limitations results in a small amount of BOD loading relative to the large amount of dilution occurring in the receiving water at critical conditions. Technology-based limitations will be protective of dissolved oxygen criteria in the receiving water.

The impact of BOD on the receiving water was modeled using **Streeter-Phelps Model (EPA, 1985)**, at critical condition and with the technology-based effluent limitation for BOD_5 described under "Technology-Based Effluent Limitations" above. The Streeter-Phelps Model calculations used to determine dissolved oxygen impacts are shown in Appendix C, table C6.

pH—WAC 173-201A-030 for Class A water requires that "pH be within the range of 6.5 to 8.5 with a human caused variation within a range of less than 0.5 units." The previous permit (issued in 1994) allowed the following exemptions:

1. The total time during which the pH values are outside the required range of pH values shall not exceed 4 hours in any calendar month.

2. No individual excursion from the range of pH values shall exceed 30 minutes.

Several short duration excursions of pH were recorded over the last two years. The excursions were the result of broken valves or valves left open in the production process and were quickly corrected. The duration of the excursions lasted from a few minutes to less than 30 minutes and never exceeded 30 minutes during any month.

Potential for violation of water quality pH standards was modeled using PHMIX2 model (see appendix C). The impact of pH was modeled using the calculations from EPA, 1988. The input variables included a dilution factor of 27, upstream temperature of 21.1°C, upstream pH of 8.44, upstream alkalinity 51 (as mg $CaCO_3$/L), effluent temperature 32.6°C, effluent pH of 9, and effluent alkalinity 51 (as mg $CaCO_3$/L). The upstream pH values are based on data from Ecology's Environmental Assessment Program 90th percentile for the Columbia River at Vernita (Ecology, 2000).

Water quality standards allow a 0.5 pH increase due to human caused variation. The effluent pH was well within the 0.5 units. Because the increase was less than 0.1 there would be no violation of the pH criteria for the receiving water. The pH model calculations may be found in Appendix C, Table C7.

Temperature—The impact of the discharge on receiving water temperature was modeled using the results of the UM Plumes model and by using a conservative energy balance equation. The temperature evaluation used a range of temperature of 20 °C to 21.1°C for ambient conditions; a temperature of 32.2 °C for effluent conditions; and a river flow range of 0.37 ft/s to 3.7 ft/s. In the 1994 fact sheet, an ambient temperature scenario of 12.0 °C was run. However, a comparable model run was not conducted this time because the water quality standards allow an incremental increase in temperature below 20 °C that is much less stringent. As noted above, the standards

allow an incremental increase of t=34/(T+9) where T is the ambient temperature. At 12 °C, using the above formula the allowable incremental increase is 1.6 °C rather than the 0.3 °C allowed above 20 °C. At an ambient river temperature of 20 °C, the allowable incremental increase is 1.3 °C.

From all of the modeling on dilution factors, it is clear that the applicant's discharge will not have a problem meeting standards when the ambient temperature is below 20 °C. Above 20 °C the discharge just meets the water quality standards if the effluent is kept within specified temperature ranges and flow volume of the effluent. These are nearly the same temperature values described by the 1994 permit.

The critical condition for temperature occurs at the maximum effluent discharge of 40 mgd, and minimum river flow (44,000 cfs) which results in a mixing dilution factor of 27 to 1. A series of model runs were conducted with the following input parameters and resultant dilution factors.

Table 7: Dilution Model Results and Input Factors

Effluent Flow (MGD)	Effluent Temp (°C)	Ambient Temp (°C)	Ambient Velocity (ft/s)	Acute Dilution factor	Chronic Dilution factor
19	32.2	21.1	0.37	24	41
19	32.2	21.1	1.5	22	137
19	32.2	21.1	3.7	16	139
19	32.2	17.5	3.7	15	119
28	32.2	21.1	0.37	18	32
28	32.2	21.1	1.5	19	98
28	32.2	21.1	3.7	16	98
40	32.2	21.1	0.37	**15**	**27**
40	32.2	21.1	1.5	17	73
40	32.2	21.1	3.7	18	80

The lowest dilution factor at the acute boundary was 15 to 1 and the lowest dilution factor at the chronic boundary was 27 to 1.

A simple energy balance equation was used in order to determine what effluent temperature would cause the applicant to exceed water quality standards at the edge of the mixing zone. This energy balance equation is:

$$Q_{ambient}(T_{ambient})+Q_{effluent}(T_{effluent}) = (Q_{ambient}+Q_{effluent})(T_{mixture})$$

Solving for the mixed temperature and incorporating the dilution factor yields the following equation:

$$T_{mix} = (T_{eff} + (DF - 1)(T_{amb}))/DF$$ Where DF is the Dilution Factor.

With a predicted dilution of 27 at the mixing zone boundary, T_{eff} of 33.2 ^{o}C, and T_{amb} of 21.1 ^{o}C the predicted temperature at the edge of the mixing zone is 21.417 as shown in table 8.

Tables 8, 9, and 10 show the cut-off points where water quality standards are no longer met (marked with a YES for being over the water quality standard). These tables are the result of several runs of the energy balance equation with different effluent temperatures and varying effluent flow.

Table 8: Calculation of Compliance with Water Quality Standards at the edge of the mixing zone

(The dilution factor for this analysis is based on a flow of 19 mgd. See table 7)

$T_{effluent}$ (^{o}C)	$T_{ambient}$ (^{o}C)	DF	$T_{mix\ (chronic)}$ (^{o}C)	T_{mix}-T_{amb} (^{o}C)	Over std?
33.3	21.1	40	21.39756	0.298	NO
33.4	21.1	40	21.40000	0.300	YES

Table 9: Calculation of Compliance with Water Quality Standards at the edge of the mixing zone

(The dilution factor for this analysis is based on a flow of 28 mgd. See table 7)

$T_{effluent}$ (^{o}C)	$T_{ambient}$ (^{o}C)	DF	$T_{mix\ (chronic)}$ (^{o}C)	T_{mix}-T_{amb} (^{o}C)	Over std?
30.6	21.1	32	21.39688	0.297	NO
30.7	21.1	32	21.40000	0.301	YES

Table 10: Calculation of Compliance with Water Quality Standards at the edge of the mixing zone

(The dilution factor for this analysis is based on the maximum allowable effluent flow of 40 mgd. See table 7)

$T_{effluent}$ (^oC)	$T_{ambient}$ (^oC)	DF	$T_{mix\ (chronic)}$ (^oC)	T_{mix}-T_{amb} (^oC)	Over std?
29.0	21.1	27	21.3963	0.297	NO
29.1	21.1	27	21.4000	0.300	**YES**

A summary of temperature limits are shown in table 11. At 19 mgd, the upper effluent temperature limit at which the temperature is met is 33.3 ^oC and at 40 mgd the upper effluent temperature limit is 29.0 ^oC. These values are 3-5 ^oC less than those issued in the 1994 permit.

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Table 11: Maximum Allowable Effluent Temperature Limits

Effluent Flow	Maximum Temperature	Allowable Increase at mixing zone boundary
19 mgd or less	**33.3 ^{o}C** (91.6 ^{o}F)	0.3 ^{o}C
19 – 28 mgd	**30.6 ^{o}C** (87.1 ^{o}F)	0.3 ^{o}C
28 – 40.0 mgd	**29.0 ^{o}C** (84.2 ^{o}F)	0.3 ^{o}C

If a TMDL is completed during the life of this permit, these limits may be replaced by Waste Load Allocations of a TMDL.

Toxic Pollutants—The Department has determined, based on the NPDES application, the chemicals used in the manufacturing process, and the relative volume of non-contact water to contact water, that there is no reasonable potential for toxic metals and organic chemicals to be discharged in the plant effluent in quantities that exceed the water quality criteria. Modeling analysis has been conducted for ammonia, which is known to be present and is monitored in the effluent.
The Department of Ecology has regularly received requests from the Permittee to discharge neutralized 10% HCl cleaning solution from the plant heat exchanger units during periodic "turn-arounds" or maintenance shutdowns. The maximum rate of discharge has generally been 35 gpm with a total discharge volume not exceeding 2,000 gallons. The Department has also received requests to discharge approximately 6000 gallons of fluid used as compressor coolant, which may contain corrosion inhibitor (sodium hydroxide, sodium nitrate, and sodium molybdate). The Permittee will be required to characterize and determine if wash-down of heat

exchanger units with acid solution produces metals and other toxins in quantity that may violate water quality standards prior to receiving Ecology approval to discharge.

Whole Effluent Toxicity

The Water Quality Standards for Surface Waters require that the effluent not cause toxic effects in the receiving waters. Many toxic pollutants cannot be detected by commonly available detection methods. However, toxicity can be measured directly by exposing living organisms to the wastewater in laboratory tests and measuring the response of the organisms. Toxicity tests measure the aggregate toxicity of the whole effluent, and therefore this approach is called whole effluent toxicity (WET) testing. Some WET tests measure acute toxicity and other WET tests measure chronic toxicity.

Acute toxicity tests measure mortality as the significant response to the toxicity of the effluent. Dischargers who monitor their wastewater with acute toxicity tests are providing an indication of the potential lethal effect of the effluent to organisms in the receiving environment.

Chronic toxicity tests measure various sublethal toxic responses such as retarded growth or reduced reproduction. Chronic toxicity tests often involve either a complete life cycle test of an organism with an extremely short life cycle or a partial life cycle test on a critical stage of one of a test organism's life cycles. Organism survival is also measured in some chronic toxicity tests.

Accredited WET testing laboratories have the proper WET testing protocols, data requirements, and reporting format. Accredited laboratories are knowledgeable about WET testing and capable of calculating an NOEC, LC_{50}, EC_{50}, IC_{25}, etc. All accredited labs have been provided the most recent version of the Department of Ecology Publication # WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria* which is referenced in the permit. Any Permittee interested in receiving a copy of this publication may call the Ecology Publications Distribution Center 360-407-7472 for a copy. Ecology recommends that Permittees send a copy of the acute or chronic toxicity sections(s) of their permits to their laboratory of choice.

The WET tests during effluent characterization indicate that no reasonable potential exists to cause receiving water acute toxicity. The Permittee will not be given an acute WET limit. The Permittee will only be required to retest the effluent prior to application for permit renewal in order to demonstrate that acute toxicity has not increased in the effluent. However, there were chronic toxicity problems as noted below and the Permittee will be required to test for chronic toxicity. Because of the possibility of interference in testing caused by fish pathogens, it is recommended that the permittee consult Ecology Publication No. WQ-R-95-80. This publication provides instructions on controlling fish pathogens during the chronic testing.

If the Permittee makes process or material changes which, in the Department's opinion, results in an increased potential for effluent toxicity, then the Department may require additional effluent characterization in a regulatory order, by permit modification, or in the permit renewal. Toxicity is assumed to have increased if WET testing conducted for submission with a permit application fails to meet the performance standards in WAC 173-205-020, "whole effluent toxicity performance standard". The Permittee may demonstrate to the Department that changes have not

increased effluent toxicity by performing additional WET testing after the time the process or material changes have been made.

Chronic toxicity was also measured during effluent characterization in the previous permit term. This toxicity was found to be at levels that, in accordance with WAC 173-205-050(2)(a), have a reasonable potential to cause receiving water toxicity. Problems were identified with the previous chronic testing. The permittee will be required to perform some additional chronic testing in the first year of the permit term. If chronic toxicity is detected at significant levels the permittee will have a chronic toxicity limit and will be required to routinely monitor for compliance.

Human Health

Washington's water quality standards now include 91 numeric health-based criteria that must be considered in NPDES permits. These criteria were promulgated for the state by the U.S. EPA in its National Toxics Rule (Federal Register, Volume 57, No. 246, Tuesday, December 22, 1992).

The Department has determined that the applicant's discharge is unlikely to contain chemicals regulated for human health, and does not contain chemicals of concern based on existing data or knowledge. The discharge will be re-evaluated for impacts to human health at the next permit reissuance.

Sediment Quality

The Department has promulgated aquatic sediment standards (Chapter 173-204 WAC) to protect aquatic biota and human health. These standards state that the Department may require Permittees to evaluate the potential for the discharge to cause a violation of applicable standards (WAC 173-204-400).

The discharge from this facility contains suspended solids that average about 0.76 mg/l (159 lbs/day). These additional solids have the potential to settle out of suspension and deposit onto the Columbia River bed, and to cause a violation of the sediment quality standards.

The Department has been unable to determine at this time the potential for this discharge to cause a violation of sediment quality standards. If the Department determines in the future that there is a potential for violation of the Sediment Quality Standards, an order will be issued to require the Permittee to demonstrate that either the point of discharge is not an area of deposition or, if the point of discharge is a depositional area, that there is not an accumulation of toxics in the sediments. Examination by divers has not found evidence of sediments settling out. Only a cobble substrate was found in the vicinity of the outfall. However if evidence is found in the future, Ecology may open the permit to reexamine sediment limits.

GROUND WATER QUALITY LIMITATIONS

The Department has promulgated Ground Water Quality Standards (Chapter 173-200 WAC) to protect beneficial uses of ground water. Permits issued by the Department shall be conditioned in such a manner so as not to allow violations of those standards (WAC 173-200-100). The Permittee has in the past impacted ground water, and is currently under a state discharge permit (ST-9164) to pump, treat and discharge high nitrate water to crops and the ground. Other measures to protect ground water are covered under Stormwater General Permit No. SO3-001427. Because this element is covered under a separate permit, there are no limitations in this permit that are required based on potential effects to ground water. The discharge that is covered by this permit (NPDES, WA-000367-1) discharges to the Columbia River and does not have an impact to ground water.

COMPARISON OF EFFLUENT LIMITS WITH THE EXISTING PERMIT ISSUED IN 1994

	Existing Limits		Proposed Limits	
Parameter	Monthly Average	Daily Maximum	Monthly Average	Daily Maximum
Flow (mgd)	36.4	40.0	36.4	40.0
pH	6.0-9.0	--	6.0-9.0	--
Temperature (°C)	--	38.3°C at 19 mgd or less 34.3°C at 19 – 28 mgd 32.5°C at 28 – 40 mgd		33.1°C at 19 mgd or less 30.6°C at 19 – 28 mgd 29°C at 28 – 40 mgd
Ammonia	108 lbs/day	341.6 lbs/day	108 lbs/day	341.6 lbs/day
Nitrate	206.7 lbs/day	610.3 lbs/day	206.7 lbs/day	610.3 lbs/day
Whole Effluent Toxicity			Chronic limit: "No statistically significant difference in test organism response between the chronic critical effluent concentration (CCEC), **3.7**% of the effluent, and the control." (See permit section S7)	

MONITORING REQUIREMENTS

Monitoring, recording, and reporting are required (WAC 173-220-210 and 40 CFR 122.41) to verify that the treatment process is functioning correctly and the effluent limitations are being achieved.

The monitoring schedule is detailed in the proposed permit under Condition S.2. Specified monitoring frequencies take into account the quantity and variability of the discharge, the treatment method, past compliance, significance of pollutants, and cost of monitoring.

LAB ACCREDITATION

With the exception of certain parameters the permit requires all monitoring data to be prepared by a laboratory registered or accredited under the provisions of Chapter 173-50 WAC, *Accreditation of Environmental Laboratories.* The laboratory at this facility is accredited for General Chemistry.

OTHER PERMIT CONDITIONS

REPORTING AND RECORDKEEPING

The conditions of S3. are based on the authority to specify any appropriate reporting and record keeping requirements to prevent and control waste discharges (WAC 173-220-210).

NON-ROUTINE AND UNANTICIPATED DISCHARGES

Occasionally, this facility may generate wastewater which is not characterized in their permit application because it is not a routine discharge and was not anticipated at the time of application. These typically are waters used to pressure test storage tanks or fire water systems or leaks from drinking water systems. These are typically clean waste waters, but may be contaminated with pollutants. The permit contains an authorization for non-routine and unanticipated discharges. The permit requires a characterization of these waste waters for pollutants and examination of the opportunities for reuse. Depending on the nature and extent of pollutants in this wastewater and opportunities for reuse, Ecology may authorize a direct discharge via the process wastewater outfall or through a stormwater outfall for clean water, require the wastewater to be placed through the facilities wastewater treatment process or require the water to be reused. The facility applied for and received Stormwater General Permit No. SO3-001427.

SPILL PLAN

The Department has determined that the Permittee stores a quantity of chemicals that have the potential to cause water pollution if accidentally released. The Department has the authority to

require the Permittee to develop best management plans to prevent this accidental release under section 402(a)(1) of the Federal Water Pollution Control Act (FWPCA) and RCW 90.48.080.

The Permittee has developed a plan for preventing the accidental release of pollutants to state waters and for minimizing damages if such a spill occurs. The proposed permit requires the Permittee to update this plan and submit it to the Department.

SOLID WASTE PLAN

The Department has determined that the Permittee has a potential to cause pollution of the waters of the state from leachate of solid waste.

This proposed permit requires, under authority of RCW 90.48.080, that the Permittee develop a solid waste plan to prevent solid waste from causing pollution of waters of the state. The plan must be submitted to the local permitting agency for approval, if necessary, and to the Department.

OUTFALL EVALUATION

Proposed permit condition S.8 requires the Permittee to conduct an outfall inspection and submit a report detailing the findings of that inspection. The purpose of the inspection is to determine the condition of the discharge pipe and diffusers and to evaluate the extent of sediment accumulations in the vicinity of the outfall.

OPERATION AND MAINTENANCE

In accordance with state and federal regulations, the Permittee is required to take all reasonable steps to properly operate and maintain the treatment system (40 CFR 122.41(e)) and WAC 173-220-150 (1)(g).

GENERAL CONDITIONS

General Conditions are based directly on state and federal law and regulations and have been standardized for all individual industrial NPDES permits issued by the Department.

PERMIT ISSUANCE PROCEDURES

PERMIT MODIFICATIONS

The Department may modify this permit to impose numerical limitations, if necessary to meet Water Quality Standards for Surface Waters, Sediment Quality Standards, or Water Quality Standards for Ground Waters, based on new information obtained from sources such as inspections, effluent monitoring, outfall studies, and effluent mixing studies.

The Department may also modify this permit as a result of new or amended state or federal regulations.

RECOMMENDATION FOR PERMIT ISSUANCE

This proposed permit meets all statutory requirements for authorizing a wastewater discharge, including those limitations and conditions believed necessary to control toxics, protect human health, aquatic life, and the beneficial uses of waters of the State of Washington. The Department proposes this permit be issued for **five** years. However, the permit may need to be reopened and re-examined if there is a TMDL completed for this section of the Columbia River or if the State Water Quality Standards are re-adopted with new criteria that apply to this permit.

REFERENCES FOR TEXT AND APPENDICES

Environmental Protection Agency (EPA)

1992. National Toxics Rule. Federal Register, V. 57, No. 246, Tuesday, December 22, 1992.

1991. Technical Support Document for Water Quality-based Toxics Control. EPA/505/2-90-001.

1988. Technical Guidance on Supplementary Stream Design Conditions for Steady State Modeling. USEPA Office of Water, Washington, D.C.

1987. Quality Criteria for Water 1986. (AKA: "The Goldbook.") EPA 440/5-86-001

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1983. Water Quality Standards Handbook. USEPA Office of Water, Washington, D.C.

Tsivoglou, E.C., and J.R. Wallace.

1972. Characterization of Stream Reaeration Capacity. EPA-R3-72-012. (Cited in EPA 1985 op.cit.)

Washington State Department of Ecology (Ecology).

2000. Environmental Assessment Program Data Base on-line http://www.ecy.wa.gov/programs/eap/fw_riv/rv_list.html

1994. Permit Writer's Manual. Publication Number 92-109

Williams, V.R., and H.E. Pearson

1985. United States Geological Survey (USGS) Stream flow Statistics and Drainage-Basin Characteristics for the Southwestern and Eastern Regions, Washington. Vol. II Eastern, WA. USGS 84-145-B

Wright, R.M., and A.J. McDonnell.

1979. In-stream Deoxygenation Rate Prediction. Journal Environmental Engineering Division, ASCE. 105(EE2). (Cited in EPA 1985 op.cit.)

APPENDIX A -- PUBLIC INVOLVEMENT INFORMATION

The Department has tentatively determined to reissue a permit to the applicant listed on page 1 of this fact sheet. The permit contains conditions and effluent limitations which are described in the rest of this fact sheet.

The Department published a Public Notice of Draft (PNOD) on March 26, 2002 in The Tri-City Herald to inform the public that a draft permit and fact sheet were available for review. Interested persons were invited to submit written comments regarding the draft permit. The draft permit, fact sheet, and related documents were available for inspection and copying between the hours of 8:00 a.m. and 5:00 p.m. weekdays, by appointment, at the regional office listed below. Written comments were mailed to:

Water Quality Permit Coordinator
Department of Ecology
Central Regional Office
15 West Yakima Avenue
Yakima, WA 98902

The Department considered all comments received within thirty (30) days from the date of public notice of draft indicated above, in formulating a final determination to issue, revise, or deny the permit. The Department's response to all significant comments is available upon request and will be mailed directly to people expressing an interest in this permit.
Further information may be obtained from the Department by telephone, 360/407-6916, or by writing to:

Water Quality Permit Coordinator
Department of Ecology
SWFA Industrial Section
PO Box 47706
Olympia, WA 98504-7706

This permit and fact sheet were written by **Eric Schlorff.**

APPENDIX B -- GLOSSARY

Acute Toxicity--The lethal effect of a compound on an organism that occurs in a short period of time, usually 48 to 96 hours.

AKART-- An acronym for "all known, available, and reasonable methods of treatment".

Ambient Water Quality--The existing environmental condition of the water in a receiving water body.

Ammonia--Ammonia is produced by the breakdown of nitrogenous materials in wastewater. Ammonia is toxic to aquatic organisms, exerts an oxygen demand, and contributes to eutrophication. It also increases the amount of chlorine needed to disinfect wastewater.

Average Monthly Discharge Limitation --The average of the measured values obtained over a calendar month's time.

Best Management Practices (BMPs)--Schedules of activities, prohibitions of practices, maintenance procedures, and other physical, structural and/or managerial practices to prevent or reduce the pollution of waters of the State. BMPs include treatment systems, operating procedures, and practices to control: plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage. BMPs may be further categorized as operational, source control, erosion and sediment control, and treatment BMPs.

BOD_5--Determining the Biochemical Oxygen Demand of an effluent is an indirect way of measuring the quantity of organic material present in an effluent that is utilized by bacteria. The BOD_5 is used in modeling to measure the reduction of dissolved oxygen in a receiving water after effluent is discharged. Stress caused by reduced dissolved oxygen levels makes organisms less competitive and less able to sustain their species in the aquatic environment. Although BOD is not a specific compound, it is defined as a conventional pollutant under the federal Clean Water Act.

Bypass--The intentional diversion of waste streams from any portion of a treatment facility.

Chlorine--Chlorine is used to disinfect wastewaters of pathogens harmful to human health. It is also extremely toxic to aquatic life.

Chronic Toxicity--The effect of a compound on an organism over a relatively long time, often 1/10 of an organism's lifespan or more. Chronic toxicity can measure survival, reproduction or growth rates, or other parameters to measure the toxic effects of a compound or combination of compounds.

Clean Water Act (CWA)--The Federal Water Pollution Control Act enacted by Public Law 92-500, as amended by Public Laws 95-217, 95-576, 96-483, 97-117; USC 1251 et seq.

Compliance Inspection - Without Sampling--A site visit for the purpose of determining the compliance of a facility with the terms and conditions of its permit or with applicable statutes and regulations.

Compliance Inspection - With Sampling--A site visit to accomplish the purpose of a Compliance Inspection - Without Sampling and as a minimum, sampling and analysis for all parameters with limits in the permit to ascertain compliance with those limits; and, for municipal facilities, sampling of influent to ascertain compliance with the 85 percent removal requirement. Additional sampling may be conducted.

Composite Sample--A mixture of grab samples collected at the same sampling point at different times, formed either by continuous sampling or by mixing discrete samples. May be "time-composite"(collected at constant time intervals) or "flow-proportional" (collected either as a constant sample volume at time intervals proportional to stream flow, or collected by increasing the volume of each aliquot as the flow increased while maintaining a constant time interval between the aliquots.

Construction Activity--Clearing, grading, excavation and any other activity which disturbs the surface of the land. Such activities may include road building, construction of residential houses, office buildings, or industrial buildings, and demolition activity.

Continuous Monitoring –Uninterrupted, unless otherwise noted in the permit.

Critical Condition--The time during which the combination of receiving water and waste discharge conditions have the highest potential for causing toxicity in the receiving water environment. This situation usually occurs when the flow within a water body is low, thus, its ability to dilute effluent is reduced.

Dilution Factor--A measure of the amount of mixing of effluent and receiving water that occurs at the boundary of the mixing zone. Expressed as the inverse of the percent effluent fraction e.g., a dilution factor of 10 means the effluent comprises 10% by volume and the receiving water 90%.

Engineering Report--A document which thoroughly examines the engineering and administrative aspects of a particular domestic or industrial wastewater facility. The report shall contain the appropriate information required in WAC 173-240-060 or 173-240-130.

Fecal Coliform Bacteria--Fecal coliform bacteria are used as indicators of pathogenic bacteria in the effluent that are harmful to humans. Pathogenic bacteria in wastewater discharges are controlled by disinfecting the wastewater. The presence of high numbers of fecal coliform bacteria in a water body can indicate the recent release of untreated wastewater and/or the presence of animal feces.

Grab Sample--A single sample or measurement taken at a specific time or over as short period of time as is feasible.

Industrial Wastewater--Water or liquid-carried waste from industrial or commercial processes, as distinct from domestic wastewater. These wastes may result from any process or activity of industry, manufacture, trade or business, from the development of any natural resource, or from animal operations such as feed lots, poultry houses, or dairies. The term includes contaminated storm water and, also, leachate from solid waste facilities.

Major Facility--A facility discharging to surface water with an EPA rating score of > 80 points based on such factors as flow volume, toxic pollutant potential, and public health impact.

Maximum Daily Discharge Limitation--The highest allowable daily discharge of a pollutant measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. The daily discharge is calculated as the average measurement of the pollutant over the day.

Method Detection Level (MDL)--The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is above zero and is determined from analysis of a sample in a given matrix containing the analyte.

Minor Facility--A facility discharging to surface water with an EPA rating score of < 80 points based on such factors as flow volume, toxic pollutant potential, and public health impact.

Mixing Zone--An area that surrounds an effluent discharge within which water quality criteria may be exceeded. The area of the authorized mixing zone is specified in a facility's permit and follows procedures outlined in state regulations (Chapter 173-201A WAC).

National Pollutant Discharge Elimination System (NPDES)--The NPDES (Section 402 of the Clean Water Act) is the Federal wastewater permitting system for discharges to navigable waters of the United States. Many states, including the State of Washington, have been delegated the authority to issue these permits. NPDES permits issued by Washington State permit writers are joint NPDES/State permits issued under both State and Federal laws.

pH--The pH of a liquid measures its acidity or alkalinity. A pH of 7 is defined as neutral, and large variations above or below this value are considered harmful to most aquatic life.

Quantitation Level (QL)-- A calculated value five times the MDL (method detection level).

Responsible Corporate Officer-- A president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy- or decision-making functions for the corporation, or the manager of one or more manufacturing, production, or operating facilities employing more than 250 persons or have gross annual sales or expenditures exceeding $25 million (in second quarter 1980 dollars), if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures (40 CFR 122.22).

Technology-based Effluent Limit--A permit limit that is based on the ability of a treatment method to reduce the pollutant.

Total Suspended Solids (TSS)--Total suspended solids is the particulate material in an effluent. Large quantities of TSS discharged to a receiving water may result in solids accumulation. Apart from any toxic effects attributable to substances leached out by water, suspended solids may kill fish, shellfish, and other aquatic organisms by causing abrasive injuries and by clogging the gills and respiratory passages of various aquatic fauna. Indirectly, suspended solids can screen out light and can promote and maintain the development of noxious conditions through oxygen depletion.

State Waters--Lakes, rivers, ponds, streams, inland waters, underground waters, salt waters, and all other surface waters and watercourses within the jurisdiction of the state of Washington.

Stormwater--That portion of precipitation that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes, and other features of a storm water drainage system into a defined surface water body, or a constructed infiltration facility.

Upset--An exceptional incident in which there is unintentional and temporary noncompliance with technology-based permit effluent limitations because of factors beyond the reasonable control of the Permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, lack of preventative maintenance, or careless or improper operation.

Water Quality-based Effluent Limit--A limit on the concentration of an effluent parameter that is intended to prevent the concentration of that parameter from exceeding its water quality criterion after it is discharged into a receiving water.

APPENDIX C -- TECHNICAL CALCULATIONS

Several of the Excel® spreadsheet tools used to evaluate a discharger's ability to meet Washington State water quality standards can be found on the Department's homepage at http.www:wa.gov.ecology.

Table C1: Acute Toxicity Test with Whole Effluent

Agrium/Prodica/Unocal Petroleum, Kennewick Acute WET Test Results as % Survival in 100 % Effluent

Lab	Test.	Species	SampleDate	Test Date	Protocol	Duration	% Survival
ORCHM	AQTX0133	Daphnia pulex	11/30/94	12/1/94	EPAA 91	48 hours	100
ORCHM	AQTX0134	Fathead Minnow	11/30/94	12/1/94	EPAA 91	96 hours	100
ORCHM	RMAR130	Daphnia pulex	3/1/95	3/2/95	EPAA 91	48 hours	100
ORCHM	RMAR131	Fathead Minnow	3/1/95	3/2/95	EPAA 91	96 hours	90
ORCHM	AQTX0310	Fathead Minnow	6/21/95	6/22/95	EPAA 91	96 hours	95
ORCHM	AQTX0311	Daphnia pulex	6/21/95	6/22/95	EPAA 91	48 hours	100
ORCHM	AQTX0895	Daphnia pulex	9/20/95	9/21/95	EPAA 91	48 hours	100
ORCHM	AQTX0896	Fathead Minnow	9/20/95	9/21/95	EPAA 91	96 hours	100
ORCHM	AQTX0900	Fathead Minnow	8/26/96	8/26/96	EPAA 91	96 hours	100
ORCHM	AQTX0899	Daphnia pulex	8/27/96	8/29/96	EPAA 91	48 hours	100

Table C2: Chronic Toxicity Test with Whole Effluent

Agrium/Prodica/Unocal Petroleum, Kennewick Chronic WET Test Results as NOEC/LOEC in % Effluent

Lab	Test	Species	SampleDate	Test Date	Protocol	End Point	NOEC	LOEC
ORCHM	AQTX0135	Ceriodaphnia dubia	11/30/94	12/1/94	EPAF 89	7d Proportion Survived	100	> 100
						Reproduction	50	100
ORCHM	AQTX0136	Fathead Minnow	11/30/94	12/1/94	EPAF 89	7d Proportion Survived	100	> 100
						Mean Weight	100	> 100
ORCHM	RMAR132	Fathead Minnow	3/1/95	3/2/95	EPAF 89	7d Proportion Survived	50	100
						Mean Biomass	50	100
						Mean Weight	100	> 100
ORCHM	RMAR133	Ceriodaphnia dubia	3/20/95	3/21/95	EPAF 89	7d Proportion Survived	100	> 100
						Reproduction	100	> 100
ORNAS	AQTX0313	Ceriodaphnia dubia	6/21/95	6/22/95	EPAF 89	7d Proportion Survived	100	> 100
						Reproduction	100	> 100
ORCHM	AQTX0312	Fathead Minnow	6/21/95	6/22/95	EPAF 89	7d Proportion Survived	2.7	6.25
						Mean Weight	100	> 100
ORCHM	AQTX0897	Ceriodaphnia dubia	9/20/95	9/21/95	EPAF 89	7d Proportion Survived	100	> 100
						Reproduction	100	> 100
ORCHM	AQTX0898	Fathead Minnow	9/20/95	9/21/95	EPAF 89	7d Proportion Survived	6.25	10
						Mean Weight	100	> 100
						Mean Biomass	10	50
ORCHM	AQTX0901	Ceriodaphnia dubia	8/22/96	8/23/96	EPAF 94	7d Proportion Survived	100	> 100
						Reproduction	100	> 100
ORCHM	AQTX0902	Fathead Minnow	8/22/96	8/23/96	EPAF 94	7d Proportion Survived	10	50
						Mean Weight	100	> 100
						Mean Biomass	10	50

Table C3: Freshwater Ammonia Concentrations and Criteria Calculations

Agrium Kennewick area plant

INPUT

1.	Ambient Temperature (deg C; 0<T<30)	21.1
2.	Ambient pH (6.5<pH<9.0)	8.44
3.	Acute TCAP (Salmonids present- 20; absent- 25)	20
4.	Chronic TCAP (Salmonids present- 15; absent- 20)	15

OUTPUT

1.	Intermediate Calculations:	
	Acute FT	1.00
	Chronic FT	1.41
	FPH	1.00
	RATIO	14
	pKa	9.37
	Fraction Of Total Ammonia Present As Un-ionized	10.5973%
2.	Un-ionized Ammonia Criteria	
	Acute (1-hour) Un-ionized Ammonia Criterion (ug NH3/L)	260.0
	Chronic (4-day) Un-ionized Ammonia Criterion (ug NH3/L)	42.0
3.	Total Ammonia Criteria:	
	Acute Total Ammonia Criterion (mg NH3+ NH4/L)	2.5
	Chronic Total Ammonia Criterion (mg NH3+ NH4/L)	0.4
4.	Total Ammonia Criteria expressed as Nitrogen:	
	Acute Ammonia Criterion as mg N	2.0
	Chronic Ammonia Criterion as N	0.33

Table C4: Performance-Based Effluent Limits for Agrium Nitrate & Ammonia

USE EXCEL TO PERFORM THE LOGNORMAL TRANSFORMATION AND CALCULATE THE TRANSFORMED MEAN AND VARIANCE	Nitrate mg/L	Nitrate lbs/day	Ammonia mg/L	Ammonia lbs/day
LOGNORMAL TRANSFORMED MEAN =	-1.3743	1.3882	-1.8055	0.9570
'LOGNORMAL TRANSFORMED VARIANCE =	0.1714	0.12	0.4209	0.40
NUMBER OF SAMPLES/MONTH FOR COMPLIANCE MONITORING =	78	78	78	78
AUTOCORRELATION FACTOR(ne)(USE 0 IF UNKNOWN) =	0	0	0	0
E(X) =	0.2756	4.2623	0.2029	3.1880
V(X) =	0.014	2.381	0.022	5.071
VARn	0.0024	0.0017	0.0067	0.0064
MEANn=	-1.2898	1.4490	-1.5984	1.1562
VAR(Xn)=	0.000	0.031	0.000	0.065
MAXIMUM DAILY EFFLUENT LIMIT =	0.663	9.066	0.743	11.437
AVERAGE MONTHLY EFFLUENT LIMIT =	0.298	4.550	0.231	3.624

Table C5: Reasonable Potential Calculation for Ammonia

Determination of Reasonable Potential to Violate Standards at the Edge of the Mixing Zone.

Based on EPA/505/2-90-001

INPUT

Confidence Level and Probability Basis:	**0.95**
Coefficient of Variation for the Effluent Concentration (CV) (0.6 or a calculated CV if there are more than 10 data points):	**0.6**
Number of Effluent Samples or Data Points (ND):	**78**
Highest Effluent Concentration or Value (HV):	**2,960**
Dilution Factors (1/{Effluent Volume Fraction}) or plumes model	
Acute Receiving Water Dilution Factor:	**15**
Chronic Receiving Water Dilution Factor:	**27**
Water Quality Standards (Concentration)	
Acute (one-hour) Criteria:	**2,000**
Chronic (n-day) Criteria:	**330**
Upstream Receiving Water Concentration:	
Upstream Concentration for Acute Condition (7Q10): 95th%-tile	**73**
Upstream Concentration for Chronic Condition (7Q10): 90th%-tile	**73**
MECB: 1-9 data points, highest value by 2; 10-50 the highest value; >50 calculate 90th %-tile	

OUTPUT

Percentile Represented by the Highest Concentration in Data Set (p_n) = (1 - confidence level)^1/ND	.96
Normal Distribution Value for 95th Percentile	1.64
Normal Distribution Value for 96th Percentile	1.78
$\sigma^2 = \ln(CV^2+1)$	0.31
C95 = exp(1.645Sigma -0.5Sigma^2)	2.13
C96 = exp(1.778Sigma -0.5Sigma^2)	2.30
Reasonable Potential Multiplier = C95/C96	0.93
Maximum Expected Concentration of Pollutant in Effluent (MEC):	2748..90
Acute - Concentration of Pollutant at the Edge of the Mixing Zone (CP):	251.39

Chronic - Concentration of Pollutant at the Edge of the Mixing Zone (CP):	172.11
Reasonable Potential to Violate Acute Criteria at the Edge of the Mixing Zone (RP):	**NO**
Reasonable Potential to Violate Chronic Criteria at the Edge of the Mixing Zone (RP):	**NO**

Table C6: Dissolved Oxygen Analysis

Streeter-Phelps analysis of critical dissolved oxygen sag.

Agrium/Prodica/Unocal Kennewick Area

Based on Lotus File DOSAG2.WK1 Revised 19-Oct-93

INPUT

1. EFFLUENT CHARACTERISTICS

Discharge (cfs):	61.9
CBOD5 (mg/L):	1.5
NBOD (mg/L):	13.7
Dissolved Oxygen (mg/L):	9
Temperature (deg C):	32.6

2. RECEIVING WATER CHARACTERISTICS

Upstream Discharge (cfs):	44000
Upstream CBOD5 (mg/L):	1.0
Upstream NBOD (mg/L):	2.5
Upstream Dissolved Oxygen (mg/L):	9
Upstream Temperature (deg C):	21.1
Elevation (ft NGVD):	340
Downstream Average Channel Slope (ft/ft):	0.001
Downstream Average Channel Depth (ft):	24
Downstream Average Channel Velocity (fps):	0.37

3. REAERATION RATE (Base e) AT 20 deg C (day^-1): 0.69

Reference	Applic. Vel (fps)	Applic. Dep (ft)	Suggested Values
Churchill	1.5 – 6	2 - 50	0.02
O'Connor and Dobbins	.1 - 1.5	2 - 50	0.07
Owens	.1 – 6	1 - 2	0.03
Tsivoglou-Wallace	.1 – 6	.1 - 2	0.85

4. BOD DECAY RATE (Base e) AT 20 deg C (day^-1): 0.39

Reference	Suggested Value
Wright and McDonnell, 1979	0.39

OUTPUT	
1. INITIAL MIXED RIVER CONDITION	
CBOD5 (mg/L):	1.0
NBOD (mg/L):	2.5
Dissolved Oxygen (mg/L):	9.0
Temperature (deg C):	21.1
2. TEMPERATURE ADJUSTED RATE CONSTANTS (Base e)	
Reaeration (day^-1):	0.71
BOD Decay (day^-1):	0.41
3. CALCULATED INITIAL ULTIMATE CBODU AND TOTAL BODU	
Initial Mixed CBODU (mg/L):	1.5
Initial Mixed Total BODU (CBODU + NBOD, mg/L):	4.0
4. INITIAL DISSOLVED OXYGEN DEFICIT	
Saturation Dissolved Oxygen (mg/L):	8.787
Initial Deficit (mg/L):	-0.21
5. TRAVEL TIME TO CRITICAL DO CONCENTRATION (days):	1.96
6. DISTANCE TO CRITICAL DO CONCENTRATION (miles):	11.86
7. CRITICAL DO DEFICIT (mg/L):	1.03
8. CRITICAL DO CONCENTRATION (mg/L):	7.75

Table C7: Calculation of pH of a mixture of two flows.

Based on the procedure in EPA's DESCON program (EPA, 1988. Technical Guidance on Supplementary Stream Design Conditions for Steady State Modeling. USEPA Office of Water, Washington D.C.)

Based on Lotus File PHMIX2.WK1 Revised 19-Oct-93

INPUT	
1. DILUTION FACTOR AT MIXING ZONE BOUNDARY	27
1. UPSTREAM/BACKGROUND CHARACTERISTICS	
Temperature (deg C):	21.10
pH:	8.44
Alkalinity (mg CaCO3/L):	51.00
2. EFFLUENT CHARACTERISTICS	
Temperature (deg C):	32.60
pH:	8.78
Alkalinity (mg CaCO3/L):	51.00

OUTPUT	
1. IONIZATION CONSTANTS	
Upstream/Background pKa:	6.37
Effluent pKa:	6.31
2. IONIZATION FRACTIONS	
Upstream/Background Ionization Fraction:	0.99
Effluent Ionization Fraction:	1.00
3. TOTAL INORGANIC CARBON	
Upstream/Background Total Inorganic Carbon (mg CaCO3/L):	51.44
Effluent Total Inorganic Carbon (mg CaCO3/L):	51.17
4. CONDITIONS AT MIXING ZONE BOUNDARY	
Temperature (deg C):	21.56
Alkalinity (mg CaCO3/L):	51.00
Total Inorganic Carbon (mg CaCO3/L):	51.43
pKa:	6.37
pH at Mixing Zone Boundary:	8.45

Incremental difference: 8.45-8.44 = 0.01. Because the difference is less than 0.5, no limit is needed.

CH2MHILL Technical memorandum Table 2
Summary of UM3 Model-Predicted Dilutions for the Agrium Kennewick Facility Outfall
for a Range of Effluent and Receiving Water Conditions

Ecology PLUMES Model Case No.	Agium UM3 Case No.	Effluent Conditions		Ambient Conditions				Model-Predicted Centerline Dilution at Acute Zone (9.8 m)	Model-Predicted Centerline Dilution at Mixing Zone (98 m)
		Flow (mgd)	Temp. (°C)	Temp. (°C)	River Flow Condition	River Current Speed (ft/sec)	River Current Percentile		
1,12	AGR-1	19	32.2	20.0	7Q10 Low	0.37	10th	25:1	41:1
2,13	AGR-2	19	32.2	21.1	7Q10 Low	0.37	10th	24:1	41:1
	AGR-2b	19	38.3	21.1	7Q10 Low	0.37	10th	29:1	40:1
3,14	AGR-3	19	32.2	21.1	Average	1.50	50th	22:1	137:1
	AGR-3b	19	38.3	21.1	Average	1.50	50th	24:1	134:1
	AGR-4	19	32.2	17.5	7Q10 High	3.70	90th	15:1	119:1
	AGR-4b	19	38.3	21.1	7Q10 High	3.70	90th	16:1	139:1
5,16	AGR-5	28	32.2	21.1	7Q10 Low	0.37	10th	18:1	32:1
6	AGR-6	28	32.2	21.1	Average	1.50	50th	19:1	98:1
	AGR-7	28	32.2	17.5	7Q10 High	3.70	90th	16:1	98:1
7,17	AGR-7b	28	32.2	21.1	7Q10 High	3.70	90th	16:1	94:1
8,18	AGR-8	40	32.2	21.1	7Q10 Low	0.37	10th	**15:1**	**27:1**
--	AGR-10	40	32.2	21.1	Average	1.50	50th	17:1	73:1
	AGR-9	40	32.2	17.5	7Q10 High	3.70	90th	18:1	83:1
9,19	AGR-9b	40	32.2	21.1	7Q10 High	3.70	90th	18:1	80:1

Note:

a) Model cases with the addition of a "b" (i.e., AGR-2b) are the additional cases requested in Ecology's 11/06/01 email to Agrium. As shown above for cases AGR-7b and AGR-9b, there was no change in predicted dilution with the ambient temperature raised from 17.5° C to 21.1° C.

*b) The critical conditions for acute and chronic dilutions are shown as **bold** dilution values above.*

TECHNICAL MEMORANDUM CH2MHILL

Agrium Kennewick Facility - Outfall Diffuser Modeling

PREPARED FOR: Gary Hinds/Agrium
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DATE: November 26, 2001 (Final Version)

INTRODUCTION

This technical memorandum presents the updated and revised dilution modeling results for the Agrium Kennewick Area Fertilizer Plant outfall into the Columbia River (NPDES Permit No. WA-000367-1). This dilution modeling was developed to replace the modeling results that were developed by Ecology (see draft NPDES Permit Fact Sheet for Kennewick Facility, August 15, 2001). These revised dilution modeling runs became necessary when it was determined that Agrium's Kennewick Facility outfall is not situated at a 90 degree angle to the river current, but rather the outfall is positioned at an angle that is about 15 degrees to the river current direction. This additional 15 degrees of downstream angle is significant to the dilution results, and therefore Agrium and the Department of Ecology have agreed that this updated modeling was appropriate.

This final version of the Outfall Diffuser Modeling Technical Memorandum updates the October 19, 2001 version to address comments received on November 6, 2001 from Ecology.

MODELING APPROACH AND ASSUMPTIONS

Figure 1 shows the approximate location of the Agrium Kennewick Facility outfall in the Wallula Reach of the Columbia River. Figure 2 illustrates the outfall and diffuser alignment relative to the river bathymetry and ambient current direction. The diffuser is oriented 15 degrees downstream of perpendicular to the river flow and bathymetry (Figure 2). The diffuser risers and ports are all welded at 90 degrees to the diffuser pipe axis (Figure 3), and therefore the diffuser ports are all discharging at an angle that is 15 degrees inshore of the ambient current direction (refer to Figure 2).

For multiport outfall diffusers, the direction of the ambient current relative to the discharge ports is one of many important factors that determine the dilution performance achieved by a diffuser, particularly in the near field region. Previous modeling conducted by CH2M HILL in 1994 for Unocal assumed that the diffuser axis was oriented normal to the current direction, with a horizontal discharge angle ("HANG") of 90° used. Similarly, Ecology's modeling in 2001 made the same assumption. This memorandum presents the methods and results of updated modeling that was conducted using the corrected horizontal discharge angle and the updated version of the model used by Ecology.

Ecology's modeling of the Agrium Kennewick outfall was performed using the model PLUMES (Baumgartner, Frick, and Roberts, 1994). Recently, the U.S. Environmental Protection Agency has released an updated version of PLUMES that is called UM3, and it is included in the EPA's Visual Plumes model platform and interface. The UM3 discharge model was developed by EPA (Frick et al., 2000) to replace the DOS-based PLUMES program. Visual Plumes is a Windows-based mixing zone modeling application that includes several models, one of which is UM3. UM3 was applied by CH2M HILL in this update of the Agrium Kennewick Facility dilution modeling.

The dilution modeling conducted by Ecology was repeated by CH2M HILL with the updated model UM3, and with two changes to the model input. The two model input changes were as follows;

1) a change in the horizontal discharge (port) direction from 90 degrees (coflow with river current) to 105 degrees (15 degrees change) – justification provided above and in figures

2) Ecology's model runs assumed either 20.0° C or 21.1° C for all conditions, and this modeling applied both 20.0° C and 21.1° C ambient river temperatures, as well as an average ambient temperature of 17.5° C for the highest river flow months of May and June).

The 25 model cases performed by Ecology are summarized in Table 1. For this modeling effort, not every model scenario needed to be matched case for case. In reviewing the previous modeling output provided in the permit fact sheet, it was noted that several of the runs had been repeated: specifically, cases 10, 11, 20, and 21 (which are the same as cases 8, 9, 18, and 19, respectively). In the earlier modeling, Ecology conducted separate cases for acute and chronic dilutions, meaning that the dilutions at the acute and mixing zone boundaries (distances of 9.8 and 98 meters, respectively) were evaluated by separate but identical model runs (e.g. Ecology Case Nos 9 and 11).

In order to minimize the total number of runs needed, evaluation of acute and chronic dilution values were obtained from common model runs, rather than separate runs. This reduced the number of model runs needed. The final model cases run by Ecology (cases 22 through 25) are also repeats of earlier cases, but these were used to evaluate acute and chronic compliance for temperature (cases 22 and 24) and ammonia (cases 23 and 25). These final four cases were not repeated for this evaluation, since they are covered by other updated model runs.

In this memorandum, fifteen model cases were conducted to meet the Permit-writer's mixing zone study guidelines and to address Ecology's request that the modeling include the maximum permitted effluent temperature of 38.3 deg C. In addition to the critical 7Q10 low and high river flow conditions, average ambient conditions were modeled to provide typical acute and chronic dilution results.

MODEL INPUT

The receiving water and effluent characteristics and diffuser configuration are required input for modeling dilution and plume behavior. The dilution performance of the Agrium outfall diffuser

was modeled using UM3 with the following model input parameters:

- **Number, diameter, and spacing of discharge ports**: 44, 6-inch diameter ports, spaced at 4 feet (1.22 meters) on center;
- **Vertical port angle (relative to horizontal)**: 0°;
- **Angle of diffuser axis relative to ambient current direction**: 105° (directed 15° from normal in the shoreward direction);
- **Port discharge depth**: 21 feet (6.4 meters) below normal pool level of +340 feet NGVD);
- **Port elevation (above riverbed):** 18 inches (0.452 meters);
- **Effluent flow rate**: 19, 28, and 40 mgd (0.832, 1.226, and 1.752 m^3/sec, respectively);
- **Effluent temperature**: 32.2° C (90° F) typical maximum effluent temperature; and 38.3° C (100.9° F) which represents the maximum permitted effluent temperature;
- **Ambient temperature**: dry season maximums--20.0° C (68° F) and 21.1° C (70° F), annual average--17.5° (63.5° F);
- **Ambient current speed**: 0.37 ft/sec (at 7Q10 critical low river flow of 44,000 cfs), 1.52 ft/sec (average river flow of 178,000 cfs), and 3.70 ft/sec (at 7Q10 high river flow of 384,000 cfs);
- **Zone of acute criteria exceedance (acute zone)**: 32 feet (9.8 meters) downstream, 10 feet (3.0 meters) upstream;
- **Mixing zone (chronic) boundary**: 321 feet (97.8 meters) downstream, 100 feet (30 meters) upstream.

MODELING RESULTS

UM3 and most other dilution models are designed to predict or calculate the average dilution, and centerline dilutions are calculated as a secondary step in the model output. Centerline dilutions are calculated by applying a ratio of the peak concentration (centerline dilution) to an average plume concentration (average dilution across plume), and this is referred to as the peak-to-mean ratio in a plume.

To develop centerline dilutions from the model-predicted flux-average dilution values, a conservative peak-to-mean ratio of 1.44 was used. This peak-to-mean ratio is a conservative value and is consistent with guidance provided in the document *Guidance for Conducting Mixing Zone Models* (Ecology, Water Quality Program Permit Writer's Manual, January 2001). The peak-to-mean ratio of 1.44 is supported because the Agrium diffuser effectively discharges as a line plume (or equivalent slot), since the port spacing is only 4 feet. A model run was also conducted using CORMIX2 for the critical conditions (Model Case AGR-8), and the results confirm that the Agrium diffuser functions as a line plume discharge, since the CORMIX2 output categorized the first discharge module as an equivalent slot discharge (same as a line plume).

The issue of how peak-to-mean ratios are calculated by the UM3 model is presently under review by two of the authors of Visual Plumes, Dr. Walt Frick of EPA and Dr. Lorin Davis of OSU. The peak-to-mean ratio used in the UM3 model output can be checked by simply dividing the flux-average dilution ("Dilution") by the centerline ("CL-diln") in the model output. At the point of merging, the peak-to-mean value should be under 2 and approximately 1.44 if the diffuser functions as a line plume. Typically, the peak-to-mean ratios in the near field should start out large near the discharge and continually decrease up to the point where initial dilution is completed. The UM3 output do not show this pattern and some show increasing ratios over distance from the discharge. After discussion of this issue with them, they acknowledged that there is a possibility that the UM3 model is not calculating the centerline dilution properly in the model. Presently, Dr. Frick is reviewing the mathematical algorithms in the model that are used to calculate centerline dilution (concentration) values.

The results of the UM3 model runs are summarized in Table 2 and the model output are provided in Appendix A. The modeling results show that the minimum predicted centerline dilutions at the acute zone boundary is 15:1 (case AGR-8) and the maximum predicted centerline dilution is 29:1 (cases AGR-2b). The minimum dilution at the acute zone boundary is predicted with the 90th-percentile ambient river current speed and maximum effluent flow rate (40 mgd).

The modeling results also show that the minimum predicted centerline dilutions at the mixing zone (chronic) boundary is 27:1 (case AGR-8) and the maximum predicted dilution is 139:1 (case AGR-4b). The minimum dilution at the mixing zone boundary is predicted with the 90th-percentile ambient river current speed and maximum effluent flow rate (40 mgd).

The minimum predicted centerline dilutions will be applied in the completion of Agrium's NPDES permit.

REFERENCES

Baumgartner, Frick, and Roberts, 1994. *Dilution Models for Effluent Discharges, 3rd Edition.* U.S. Standards and Applied Science Division, Office of Science and Technology, Environmental Protection Agency. March 22, 1994.

Fact Sheet for Agrium NPDES permit WA-000367-1 (Draft). August 15, 2001.

Frick, W.E., P.J.W. Roberts, L.R. Davis, J. Keyes, D. J. Baumgartner, and K.P. George. *Dilution Models for Effluent Discharges, 4th Edition (Visual Plumes)*. Environmental Research Division, NERL, ORD, U.S. Environmental Protection Agency. November 22, 2000.

Washington State Department of Ecology. Water Quality Program Permit Writer's Manual: (Procedures for Writing Wastewater Discharge Permits). Publication Number 92-109. Revised January 2001.

UM3 MODEL RUNS

1:13:27 AM. amb fills:/ Windows UM3. 10/18/2001 7:32:31 AM
Case 1; ambient file C:\Plumes\agr1.001.db; Diffuser table record 1: ----------
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P-dia (m)	P-elev (m)	V-angle (deg)	H-angle (deg)	Ports ()	Spacing (m)	AcuteMZ (m)	ChrncMZ (m)	P-depth (m)	Ttl-flo (m3/s)	Eff-sal (psu)	Temp (C)	Polutnt (%)
0.1524	0.4572	0.0	105.0	44.0	1.219	9.78	97.8	6.401	0.8322	0.0	32.2	100.0

Froude number: 14.86

Step	Amb-cur (m/s)	Amb-tem (C)	P-dia (m)	Polutnt (%)	Dilutn ()	CL-diln ()	x-posn (m)	y-posn (m)	
0	0.113	20.0	0.152	100.0	1.0	1.0	0.0	0.0;	
10	0.113	20.0	0.182	82.03	1.218	1.0	-0.0193	0.0731;	
20	0.113	20.0	0.219	67.3	1.484	1.0	-0.0414	0.159;	
30	0.113	20.0	0.263	55.21	1.808	1.0	-0.0667	0.26;	
40	0.113	20.0	0.314	45.29	2.204	1.024	-0.0955	0.38;	
50	0.113	20.0	0.375	37.15	2.686	1.224	-0.128	0.521;	
60	0.113	20.0	0.445	30.48	3.273	1.458	-0.164	0.687;	
70	0.113	20.0	0.527	25.0	3.989	1.733	-0.204	0.882;	
80	0.113	20.0	0.62	20.51	4.862	2.055	-0.249	1.112;	
90	0.113	20.0	0.727	16.83	5.926	2.431	-0.297	1.381;	
100	0.113	20.0	0.849	13.8	7.224	2.871	-0.349	1.7;	
110	0.113	20.0	0.985	11.32	8.805	3.386	-0.405	2.079;	
120	0.113	20.0	1.137	9.289	10.73	3.993	-0.466	2.529;	
125	0.113	20.0	1.22	8.414	11.85	4.353	-0.496	2.778;	merging,
130	0.113	20.0	1.321	7.62	13.08	4.876	-0.545	3.2;	
140	0.113	20.0	1.597	6.251	15.95	6.313	-0.653	4.22;	
150	0.113	20.0	1.972	5.128	19.44	8.615	-0.758	5.361;	
160	0.113	20.0	2.458	4.207	23.7	12.41	-0.86	6.63;	
170	0.113	20.0	3.076	3.451	28.88	14.94	-0.959	8.059;	
180	0.113	20.0	3.852	2.831	35.21	18.02	-1.056	9.692;	
181	0.113	20.0	3.939	2.776	**35.91**	**18.36**	**-1.065**	**9.869**;	**acute zone,**
190	0.113	20.0	4.815	2.323	42.92	21.76	-1.151	11.59;	
200	0.113	20.0	6.005	1.905	52.32	26.32	-1.245	13.8;	
205	0.113	20.0	6.699	1.726	57.76	28.95	-1.292	15.06;	surface,

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 57.33 m

conc (%)	dilutn	width (m)	distnce (m)	time (hrs)	(%)	(s-1)	(m/s)	(m0.67/s2)	
1.72202	57.89	58.23	20.0	0.012	0.0	0.0	0.113	4.53E-4	
1.72405	57.82	60.03	30.0	0.0367	0.0	0.0	0.113	4.53E-4	
1.72474	57.79	61.78	40.0	0.0613	0.0	0.0	0.113	4.53E-4	
1.72473	57.79	63.48	50.0	0.0859	0.0	0.0	0.113	4.53E-4	
1.72322	57.85	65.14	60.0	0.111	0.0	0.0	0.113	4.53E-4	
1.71931	57.98	66.75	70.0	0.135	0.0	0.0	0.113	4.53E-4	
1.71251	58.21	68.33	80.0	0.16	0.0	0.0	0.113	4.53E-4	
1.7033	**58.52**	**69.87**	**90.0**	0.184	0.0	0.0	0.113	4.53E-4	
1.69189	**58.92**	**71.38**	**100.0**	0.209	0.0	0.0	0.113	4.53E-4	**chronic (98 m)**

Windows UM3. 10/18/2001 7:49:03 AM
Case 2; ambient file C:\Plumes\agr2.001.db; Diffuser table record 1: ----------

P-dia (m)	P-elev (m)	V-angle (deg)	H-angle (deg)	Ports ()	Spacing (m)	AcuteMZ (m)	ChrncMZ (m)	P-depth (m)	Ttl-flo (m3/s)	Eff-sal (psu)	Temp (C)	Polutnt (%)
0.1524	0.4572	0.0	105.0	44.0	1.219	9.78	97.8	6.401	0.8322	0.0	32.2	100.0

Froude number: 15.42

Step	Depth (m)	Amb-cur (m/s)	Amb-tem (C)	P-dia (m)	Polutnt (%)	Dilutn ()	CL-diln ()	x-posn (m)	y-posn (m)	
0	6.401	0.113	21.1	0.152	100.0	1.0	1.0	0.0	0.0;	
10	6.401	0.113	21.1	0.182	82.03	1.218	1.0	-0.0193	0.0732;	
20	6.401	0.113	21.1	0.219	67.3	1.484	1.0	-0.0414	0.159;	
30	6.4	0.113	21.1	0.263	55.21	1.809	1.0	-0.0667	0.26;	
40	6.398	0.113	21.1	0.314	45.29	2.204	1.025	-0.0955	0.38;	
50	6.396	0.113	21.1	0.375	37.15	2.686	1.224	-0.128	0.521;	
60	6.392	0.113	21.1	0.445	30.48	3.274	1.459	-0.164	0.687;	
70	6.386	0.113	21.1	0.527	25.0	3.99	1.734	-0.204	0.883;	
80	6.376	0.113	21.1	0.62	20.51	4.863	2.055	-0.249	1.112;	
90	6.362	0.113	21.1	0.727	16.83	5.928	2.431	-0.297	1.382;	
100	6.341	0.113	21.1	0.849	13.8	7.225	2.871	-0.349	1.701;	
110	6.311	0.113	21.1	0.985	11.32	8.807	3.386	-0.405	2.08;	
120	6.267	0.113	21.1	1.138	9.289	10.74	3.992	-0.466	2.531;	
125	6.239	0.113	21.1	1.22	8.414	11.85	4.352	-0.497	2.782;	merging,
130	6.187	0.113	21.1	1.322	7.62	13.09	4.875	-0.547	3.212;	
140	6.028	0.113	21.1	1.599	6.251	15.95	6.312	-0.657	4.256;	
150	5.808	0.113	21.1	1.974	5.128	19.44	8.616	-0.765	5.425;	
160	5.522	0.113	21.1	2.462	4.207	23.7	12.4	-0.869	6.723;	
170	5.162	0.113	21.1	3.082	3.451	28.89	14.93	-0.97	8.184;	
180	4.712	0.113	21.1	3.859	2.831	**35.22**	**18.0**	**-1.069**	**9.853**;	**acute**
190	4.156	0.113	21.1	4.825	2.323	42.93	21.74	-1.166	11.78;	
200	3.469	0.113	21.1	6.018	1.905	52.33	26.28	-1.262	14.05;	
205	3.068	0.113	21.1	6.714	1.726	57.78	28.91	-1.31	15.32;	surface,

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 57.35 m

conc (%)	dilutn	width (m)	distnce (m)	time (hrs)	(%)	(s-1)	(m/s)	(m0.67/s2)	
1.7219	57.9	58.2	20.0	0.0114	0.0	0.0	0.113	4.53E-4	
1.72402	57.83	60.0	30.0	0.036	0.0	0.0	0.113	4.53E-4	
1.72472	57.81	61.75	40.0	0.0606	0.0	0.0	0.113	4.53E-4	
1.72474	57.81	63.45	50.0	0.0853	0.0	0.0	0.113	4.53E-4	
1.72329	57.86	65.11	60.0	0.11	0.0	0.0	0.113	4.53E-4	
1.71945	57.99	66.73	70.0	0.135	0.0	0.0	0.113	4.53E-4	
1.71274	58.21	68.31	80.0	0.159	0.0	0.0	0.113	4.53E-4	
1.70359	**58.53**	**69.85**	**90.0**	0.184	0.0	0.0	0.113	4.53E-4	
1.69223	**58.92**	**71.36**	**100.0**	0.208	0.0	0.0	0.113	4.53E-4	**chronic (98 m)**

/ Windows UM3. 11/06/2001 2:16:43 PM
Case 1; ambient file C:\Plumes**agr2b.001.db**; Diffuser table record 1: ----------

P-dia (m)	P-elev (m)	V-angle (deg)	H-angle (deg)	Ports ()	Spacing (m)	AcuteMZ (m)	ChrncMZ (m)	P-depth (m)	Ttl-flo (m3/s)	Eff-sal (psu)	Temp (C)	Polutnt (%)
0.1524	0.4572	0.0	105.0	44.0	1.219	9.78	97.8	6.401	0.8322	0.0	38.3	100.0

Froude number: 11.81

Step	Amb-cur (m/s)	Amb-tem (C)	P-dia (m)	Polutnt (%)	Dilutn ()	CL-diln ()	x-posn (m)	y-posn (m)	
0	0.113	21.1	0.152	100.0	1.0	1.0	0.0	0.0;	
10	0.113	21.1	0.182	82.03	1.218	1.0	-0.0193	0.073;	
20	0.113	21.1	0.219	67.3	1.483	1.0	-0.0413	0.158;	
30	0.113	21.1	0.262	55.21	1.807	1.0	-0.0666	0.26;	
40	0.113	21.1	0.314	45.29	2.201	1.023	-0.0953	0.379;	
50	0.113	21.1	0.374	37.15	2.682	1.222	-0.128	0.521;	
60	0.113	21.1	0.445	30.48	3.268	1.457	-0.164	0.686;	
70	0.113	21.1	0.526	25.0	3.983	1.731	-0.204	0.881;	
80	0.113	21.1	0.619	20.51	4.854	2.053	-0.248	1.11;	
90	0.113	21.1	0.726	16.83	5.917	2.43	-0.296	1.379;	
100	0.113	21.1	0.846	13.8	7.211	2.872	-0.348	1.697;	
110	0.113	21.1	0.982	11.32	8.79	3.393	-0.404	2.07;	
120	0.113	21.1	1.133	9.289	10.71	4.008	-0.46	2.489;	
125	0.113	21.1	1.214	8.414	11.83	4.366	-0.488	2.715;	merging,
130	0.113	21.1	1.313	7.62	13.06	4.893	-0.529	3.067;	
140	0.113	21.1	1.581	6.251	15.92	6.334	-0.616	3.893;	
150	0.113	21.1	1.944	5.128	19.4	8.615	-0.701	4.815;	
160	0.113	21.1	2.416	4.207	23.65	12.53	-0.784	5.846;	
170	0.113	21.1	3.015	3.451	28.83	15.12	-0.865	7.016;	
180	0.113	21.1	3.765	2.831	35.14	18.28	-0.944	8.361;	
189	0.113	21.1	4.594	2.369	42.0	**21.7**	-1.015	**9.759**;	**acute zone,**
190	0.113	21.1	4.696	2.323	42.84	22.11	-1.023	9.927;	
200	0.113	21.1	5.845	1.905	52.22	26.79	-1.101	11.77;	
204	0.113	21.1	6.376	1.76	56.52	28.93	-1.132	12.59;	surface,

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 57.01 m

conc (%)	dilutn	width (m)	distnce (m)	time (hrs)	(%)	(s-1)	(m/s)	(m0.67/s2)	
1.75731	56.62	58.36	20.0	0.0181	0.0	0.0	0.113	4.53E-4	
1.75877	56.57	60.14	30.0	0.0427	0.0	0.0	0.113	4.53E-4	
1.75932	56.55	61.87	40.0	0.0674	0.0	0.0	0.113	4.53E-4	
1.75902	56.56	63.56	50.0	0.092	0.0	0.0	0.113	4.53E-4	
1.7569	56.63	65.2	60.0	0.117	0.0	0.0	0.113	4.53E-4	
1.75215	56.79	66.8	70.0	0.141	0.0	0.0	0.113	4.53E-4	
1.74447	57.04	68.37	80.0	0.166	0.0	0.0	0.113	4.53E-4	
1.73442	57.37	69.9	90.0	0.19	0.0	0.0	0.113	4.53E-4	
1.72229	57.77	71.39	100.0	0.215	0.0	0.0	0.113	4.53E-4	**chronic (98 m)**

Windows UM3. 10/18/2001 7:41:12 AM
Case 3; ambient file C:\Plumes\agr3.001.db; Diffuser table record 1: ----------

P-dia (m)	P-elev (m)	V-angle (deg)	H-angle (deg)	Ports ()	Spacing (m)	AcuteMZ (m)	ChrncMZ (m)	P-depth (m)	Ttl-flo (m3/s)	Eff-sal (psu)	Temp (C)	Polutnt (%)
0.1524	0.4572	0.0	105.0	44.0	1.219	9.78	97.8	6.401	0.8322	0.0	32.2	100.0

Froude number: 15.42

Step	Amb-cur (m/s)	Amb-tem (C)	P-dia (m)	Polutnt (%)	Dilutn ()	CL-diln ()	x-posn (m)	y-posn (m)	
0	0.457	21.1	0.152	100.0	1.0	1.0	0.0	0.0;	
10	0.457	21.1	0.177	82.03	1.218	1.0	-0.0153	0.0601;	
20	0.457	21.1	0.205	67.3	1.484	1.0	-0.0305	0.126;	
30	0.457	21.1	0.237	55.21	1.809	1.0	-0.0467	0.205;	
40	0.457	21.1	0.272	45.29	2.204	1.0	-0.064	0.3;	
50	0.457	21.1	0.31	37.15	2.686	1.0	-0.0825	0.415;	
60	0.457	21.1	0.353	30.48	3.274	1.081	-0.103	0.558;	
70	0.457	21.1	0.4	25.0	3.99	1.276	-0.124	0.737;	
80	0.457	21.1	0.452	20.51	4.863	1.511	-0.148	0.963;	
90	0.457	21.1	0.508	16.83	5.928	1.793	-0.173	1.252;	
100	0.457	21.1	0.57	13.8	7.225	2.134	-0.201	1.624;	
110	0.457	21.1	0.638	11.32	8.807	2.547	-0.231	2.103;	
120	0.457	21.1	0.712	9.289	10.74	3.048	-0.263	2.708;	
130	0.457	21.1	0.794	7.62	13.09	3.657	-0.297	3.462;	
140	0.457	21.1	0.883	6.251	15.95	4.398	-0.331	4.391;	
150	0.457	21.1	0.982	5.128	19.44	5.301	-0.366	5.522;	
160	0.457	21.1	1.09	4.207	23.7	6.399	-0.401	6.887;	
168	0.457	21.1	1.184	3.591	27.77	7.448	-0.429	8.169;	merging,
170	0.457	21.1	1.209	3.451	28.89	7.808	-0.438	8.636;	
174	0.457	21.1	1.269	3.188	**31.27**	**8.614**	**-0.46**	**9.823**;	**acute zone,**
180	0.457	21.1	1.377	2.831	35.22	10.06	-0.492	11.75;	
190	0.457	21.1	1.604	2.323	42.93	13.37	-0.544	15.3;	
200	0.457	21.1	1.896	1.905	52.33	18.52	-0.593	19.43;	
210	0.457	21.1	2.265	1.563	63.79	27.4	-0.641	24.31;	
220	0.457	21.1	2.725	1.282	77.76	35.32	-0.688	30.12;	
230	0.457	21.1	3.294	1.052	94.78	42.99	-0.734	37.1;	
240	0.457	21.1	3.994	0.863	115.5	52.34	-0.78	45.52;	
250	0.457	21.1	4.853	0.708	140.8	63.74	-0.826	55.71;	
260	0.457	21.1	5.906	0.581	171.7	77.64	-0.872	68.07;	
267	0.457	21.1	6.779	0.506	197.2	89.14	-0.904	78.26;	surface,

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 57.41 m

conc (%)	dilutn	width (m)	distnce (m)	time (hrs)	(%)	(s-1)	(m/s)	(m0.67/s2)	
0.50322	198.1	57.49	80.0	0.00105	0.0	0.0	0.457	4.53E-4	
0.50413	**197.8**	**57.95**	**90.0**	0.00713	0.0	0.0	0.457	4.53E-4	
0.50452	**197.6**	**58.4**	**100.0**	0.0132	0.0	0.0	0.457	4.53E-4	**chronic (98 m)**

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/ Windows UM3. 11/06/2001 2:42:05 PM
Case 1; ambient file C:\Plumes\agr3b.001.db; Diffuser table record 1: ----------------------------
-------
   P-dia  P-elev V-angle H-angle   Ports Spacing AcuteMZ ChrncMZ P-depth Ttl-flo Eff-sal    Temp
Polutnt
     (m)      (m)    (deg)    (deg)      ()      (m)      (m)      (m)      (m)   (m3/s)    (psu)      (C)
(%)
  0.1524  0.4572      0.0    105.0    44.0    1.219     9.78     97.8    6.401   0.8322      0.0     38.3
100.0
Froude number:      11.81
        Depth  Amb-cur  Amb-tem    P-dia  Polutnt   Dilutn  CL-diln   x-posn   y-posn
Step      (m)    (m/s)      (C)      (m)      (%)       ()       ()      (m)      (m)
   0     6.401    0.457     21.1    0.152    100.0      1.0      1.0      0.0      0.0;
  10     6.401    0.457     21.1    0.177    82.03    1.218      1.0  -0.0153     0.06;
  20     6.401    0.457     21.1    0.205     67.3    1.483      1.0  -0.0304    0.126;
  30       6.4    0.457     21.1    0.236    55.21    1.807      1.0  -0.0466    0.204;
  40     6.399    0.457     21.1    0.271    45.29    2.201      1.0  -0.0639    0.299;
  50     6.398    0.457     21.1     0.31    37.15    2.682      1.0  -0.0824    0.415;
  60     6.396    0.457     21.1    0.353    30.48    3.268    1.079   -0.102    0.557;
  70     6.392    0.457     21.1      0.4     25.0    3.983    1.274   -0.124    0.736;
  80     6.388    0.457     21.1    0.451    20.51    4.854    1.508   -0.147    0.962;
  90     6.381    0.457     21.1    0.508    16.83    5.917     1.79   -0.173     1.25;
 100     6.371    0.457     21.1     0.57     13.8    7.211     2.13     -0.2    1.613;
 110     6.358    0.457     21.1    0.637    11.32     8.79    2.543   -0.229    2.064;
 120      6.34    0.457     21.1    0.712    9.289    10.71    3.044   -0.258    2.617;
 130     6.316    0.457     21.1    0.793     7.62    13.06    3.652   -0.288     3.29;
 140     6.286    0.457     21.1    0.882    6.251    15.92    4.393   -0.318    4.101;
 150     6.249    0.457     21.1     0.98    5.128     19.4    5.294   -0.348     5.07;
 160     6.203    0.457     21.1    1.088    4.207    23.65    6.391   -0.377    6.221;
 169     6.154    0.457     21.1    1.195     3.52    28.27    7.611   -0.403    7.434; merging,
 170     6.146    0.457     21.1    1.208    3.451    28.83    7.793   -0.407    7.616;
 180     6.043    0.457     21.1    1.375    2.831    35.14    10.04   -0.448    9.986; acute
zone,
 190     5.912    0.457     21.1    1.601    2.323    42.84    13.34   -0.488    12.75;
 200     5.752    0.457     21.1    1.892    1.905    52.22    18.46   -0.527     16.0;
 210     5.555    0.457     21.1     2.26    1.563    63.65    27.27   -0.565    19.86;
 220     5.313    0.457     21.1    2.718    1.282    77.59    35.26   -0.602    24.48;
 230     5.017    0.457     21.1    3.285    1.052    94.59    42.93   -0.639    30.04;
 240     4.655    0.457     21.1    3.984    0.863    115.3    52.26   -0.676    36.77;
 250     4.212    0.457     21.1    4.841    0.708    140.5    63.65   -0.713    44.92;
 260     3.672    0.457     21.1     5.89    0.581    171.3    77.52   -0.749    54.82;
 266     3.291    0.457     21.1    6.629    0.516    192.9    87.26   -0.771    61.76; surface,
Const Eddy Diffusivity.  Farfield dispersion based on wastefield width of      57.26 m
    conc  dilutn   width distnce    time
     (%)            (m)      (m)     (hrs)      (%)    (s-1)   (m/s)(m0.67/s2)
 0.51398   193.6   57.64     70.0 0.00501      0.0      0.0   0.457 4.53E-4
  0.5145   193.4   58.09     80.0  0.0111      0.0      0.0   0.457 4.53E-4
 0.51477   193.3   58.54     90.0  0.0172      0.0      0.0   0.457 4.53E-4 chronic zone at 98 m
 0.51493   193.2   58.99    100.0  0.0232      0.0      0.0   0.457 4.53E-4
```

Windows UM3. 10/18/2001 7:24:13 AM
Case 4; ambient file C:\Plumes\agr4.001.db; Diffuser table record 1: ----------
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P-dia (m)	P-elev (m)	V-angle (deg)	H-angle (deg)	Ports ()	Spacing (m)	AcuteMZ (m)	ChrncMZ (m)	P-depth (m)	Ttl-flo (m3/s)	Eff-sal (psu)	Temp (C)	Polutnt (%)
0.1524	0.4572	0.0	105.0	44.0	1.219	9.78	97.8	6.401	0.8322	0.0	32.2	100.0

Froude number: 13.86

Step	Amb-cur (m/s)	Amb-tem (C)	P-dia (m)	Polutnt (%)	Dilutn ()	CL-diln ()	x-posn (m)	y-posn (m)	
0	1.128	17.5	0.152	100.0	1.0	1.0	0.0	0.0;	
10	1.128	17.5	0.167	82.03	1.218	1.0	-0.0121	0.0506;	
20	1.128	17.5	0.184	67.3	1.484	1.0	-0.0235	0.111;	
30	1.128	17.5	0.202	55.21	1.808	1.0	-0.0361	0.193;	
40	1.128	17.5	0.222	45.29	2.203	1.0	-0.0499	0.304;	
50	1.128	17.5	0.244	37.15	2.685	1.0	-0.065	0.454;	
60	1.128	17.5	0.269	30.48	3.272	1.0	-0.0816	0.655;	
70	1.128	17.5	0.296	25.0	3.988	1.0	-0.0996	0.924;	
80	1.128	17.5	0.326	20.51	4.86	1.223	-0.119	1.28;	
90	1.128	17.5	0.359	16.83	5.924	1.496	-0.14	1.747;	
100	1.128	17.5	0.396	13.8	7.22	1.829	-0.162	2.356;	
110	1.128	17.5	0.436	11.32	8.801	2.235	-0.185	3.142;	
120	1.128	17.5	0.481	9.289	10.73	2.731	-0.21	4.144;	
130	1.128	17.5	0.531	7.62	13.08	3.334	-0.235	5.41;	
140	1.128	17.5	0.585	6.251	15.94	4.071	-0.261	6.988;	
150	1.128	17.5	0.646	5.128	19.43	4.968	-0.287	8.936;	
154	1.128	17.5	0.672	4.738	**21.03**	**5.38**	**-0.297**	**9.833**;	**acute zone,**
160	1.128	17.5	0.713	4.207	23.68	6.062	-0.313	11.32;	
170	1.128	17.5	0.787	3.451	28.87	7.396	-0.339	14.19;	
180	1.128	17.5	0.868	2.831	35.19	9.021	-0.365	17.65;	
190	1.128	17.5	0.958	2.323	42.9	11.0	-0.389	21.76;	
200	1.128	17.5	1.058	1.905	52.29	13.42	-0.414	26.63;	
210	1.128	17.5	1.168	1.563	63.74	16.36	-0.437	32.38;	
211	1.128	17.5	1.179	1.532	65.02	16.69	-0.439	33.01;	merging,
220	1.128	17.5	1.309	1.282	77.7	20.95	-0.467	41.3;	
230	1.128	17.5	1.507	1.052	94.72	27.64	-0.497	52.25;	
240	1.128	17.5	1.765	0.863	115.5	37.72	-0.526	65.21;	
250	1.128	17.5	2.091	0.708	140.7	54.17	-0.554	80.75;	
260	1.128	17.5	2.499	0.581	**171.6**	**77.18**	**-0.583**	**99.47**;	**chronic zone,**
270	1.128	17.5	3.005	0.476	209.1	94.09	-0.611	122.1;	
280	1.128	17.5	3.63	0.391	254.9	114.7	-0.639	149.7;	
290	1.128	17.5	4.397	0.321	310.8	139.8	-0.666	183.1;	
300	1.128	17.5	5.336	0.263	378.8	170.5	-0.694	223.8;	
310	1.128	17.5	6.486	0.216	461.8	207.8	-0.722	273.4;	surface,

Outside chronic zone
;
7:24:13 AM. amb fills:

/ Windows UM3. 11/06/2001 2:58:10 PM
Case 1; ambient file C:\Plumes**agr4b.001.db**; Diffuser table record 1: ----------
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P-dia	P-elev	V-angle	H-angle	Ports	Spacing	AcuteMZ	ChrncMZ	P-depth	Ttl-flo	Eff-sal	Temp	Polutnt
(m)	(m)	(deg)	(deg)	()	(m)	(m)	(m)	(m)	(m3/s)	(psu)	(C)	(%)
0.1524	0.4572	0.0	105.0	44.0	1.219	9.78	97.8	6.401	0.8322	0.0	38.3	100.0

Froude number: 11.81

Step	Depth (m)	Amb-cur (m/s)	Amb-tem (C)	P-dia (m)	Polutnt (%)	Dilutn ()	x-posn (m)	y-posn (m)	
0	6.401	1.128	21.1	0.152	100.0	1.0	0.0	0.0;	
10	6.401	1.128	21.1	0.167	82.03	1.218	-0.0121	0.0505;	
20	6.401	1.128	21.1	0.184	67.3	1.483	-0.0235	0.111;	
30	6.4	1.128	21.1	0.202	55.21	1.807	-0.0361	0.192;	
40	6.4	1.128	21.1	0.222	45.29	2.201	-0.0498	0.303;	
50	6.399	1.128	21.1	0.244	37.15	2.682	-0.0648	0.452;	
60	6.398	1.128	21.1	0.268	30.48	3.268	-0.0811	0.65;	
70	6.395	1.128	21.1	0.296	25.0	3.983	-0.0987	0.912;	
80	6.392	1.128	21.1	0.326	20.51	4.854	-0.117	1.257;	
90	6.388	1.128	21.1	0.359	16.83	5.917	-0.137	1.705;	
100	6.382	1.128	21.1	0.395	13.8	7.211	-0.158	2.282;	
110	6.374	1.128	21.1	0.436	11.32	8.79	-0.18	3.017;	
120	6.363	1.128	21.1	0.481	9.289	10.71	-0.203	3.942;	
130	6.349	1.128	21.1	0.53	7.62	13.06	-0.226	5.095;	
140	6.331	1.128	21.1	0.585	6.251	15.92	-0.249	6.515;	
150	6.309	1.128	21.1	0.645	5.128	19.4	-0.272	8.246;	
158	6.287	1.128	21.1	0.698	4.377	**22.73**	-0.291	**9.887**;	**acute zone,**
160	6.281	1.128	21.1	0.712	4.207	23.65	-0.295	10.34;	
170	6.247	1.128	21.1	0.786	3.451	28.83	-0.318	12.84;	
180	6.206	1.128	21.1	0.868	2.831	35.14	-0.34	15.82;	
190	6.158	1.128	21.1	0.958	2.323	42.84	-0.361	19.35;	
200	6.102	1.128	21.1	1.057	1.905	52.22	-0.382	23.51;	
210	6.037	1.128	21.1	1.167	1.563	63.65	-0.402	28.39;	
212	6.023	1.128	21.1	1.19	1.502	66.23	-0.406	29.47;	merging,
220	5.941	1.128	21.1	1.308	1.282	77.59	-0.425	35.55;	
230	5.817	1.128	21.1	1.506	1.052	94.59	-0.45	44.56;	
240	5.667	1.128	21.1	1.763	0.863	115.3	-0.474	55.3;	
250	5.484	1.128	21.1	2.089	0.708	140.5	-0.498	68.22;	
260	5.261	1.128	21.1	2.496	0.581	171.3	-0.522	83.84;	
268	5.048	1.128	21.1	2.892	0.496	200.7	-0.54	98.7;	**chronic zone,**
270	4.989	1.128	21.1	3.001	0.476	208.8	-0.545	102.8;	
280	4.659	1.128	21.1	3.625	0.391	254.6	-0.568	125.8;	
290	4.255	1.128	21.1	4.39	0.321	310.3	-0.592	153.8;	
300	3.764	1.128	21.1	5.329	0.263	378.3	-0.615	187.9;	
310	3.165	1.128	21.1	6.477	0.216	461.1	-0.638	229.4;	surface,

Outside chronic zone

/ Windows UM3. 10/18/2001 8:00:37 AM
Case 5; ambient file C:\Plumes\agr5.001.db; Diffuser table record 1: ----------
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P-dia (m)	P-elev (m)	V-angle (deg)	H-angle (deg)	Ports ()	Spacing (m)	AcuteMZ (m)	ChrncMZ (m)	P-depth (m)	Ttl-flo (m3/s)	Eff-sal (psu)	Temp (C)	Polutnt (%)
0.1524	0.4572	0.0	105.0	44.0	1.219	9.78	97.8	6.401	1.226	0.0	32.2	100.0

Froude number: 22.72

Step	Depth (m)	Amb-cur (m/s)	Amb-tem (C)	P-dia (m)	Polutnt (%)	Dilutn ()	CL-diln ()	x-posn (m)	y-posn (m)	
0	6.401	0.113	21.1	0.152	100.0	1.0	1.0	0.0	0.0;	
10	6.401	0.113	21.1	0.183	82.03	1.218	1.0	-0.0199	0.0751;	
20	6.401	0.113	21.1	0.221	67.3	1.484	1.0	-0.0431	0.164;	
30	6.4	0.113	21.1	0.266	55.21	1.809	1.0	-0.0702	0.27;	
40	6.4	0.113	21.1	0.32	45.29	2.204	1.06	-0.102	0.397;	
50	6.398	0.113	21.1	0.384	37.15	2.686	1.273	-0.138	0.546;	
60	6.396	0.113	21.1	0.459	30.48	3.274	1.526	-0.179	0.723;	
70	6.392	0.113	21.1	0.548	25.0	3.99	1.824	-0.225	0.932;	
80	6.387	0.113	21.1	0.651	20.51	4.863	2.174	-0.277	1.178;	
90	6.378	0.113	21.1	0.771	16.83	5.928	2.585	-0.335	1.467;	
100	6.364	0.113	21.1	0.909	13.8	7.225	3.066	-0.399	1.806;	
107	6.351	0.113	21.1	1.018	12.02	8.299	3.45	-0.447	2.079;	bottom hit,
110	6.344	0.113	21.1	1.067	11.32	8.807	3.628	-0.468	2.206;	
119	6.317	0.113	21.1	1.227	9.475	10.52	4.231	-0.536	2.628;	merging,
120	6.312	0.113	21.1	1.247	9.289	10.74	4.325	-0.546	2.697;	
130	6.219	0.113	21.1	1.519	7.62	13.09	5.522	-0.699	3.752;	
140	6.033	0.113	21.1	1.911	6.251	15.95	7.43	-0.89	5.209;	
150	5.743	0.113	21.1	2.437	5.128	19.44	10.76	-1.087	6.895;	
160	5.345	0.113	21.1	3.119	4.207	23.7	12.91	-1.28	8.757;	
165	5.102	0.113	21.1	3.527	3.81	**26.17**	**14.15**	**-1.374**	**9.758;**	**acute,**
170	4.828	0.113	21.1	3.987	3.451	28.89	15.51	-1.467	10.81;	
180	4.173	0.113	21.1	5.079	2.831	35.22	18.67	-1.648	13.11;	
190	3.355	0.113	21.1	6.44	2.323	42.93	22.51	-1.826	15.72;	
192	3.169	0.113	21.1	6.749	2.232	44.66	23.37	-1.861	16.29;	surface,

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 57.38 m

conc (%)	dilutn	width (m)	distnce (m)	time (hrs)	(%)	(s-1)	(m/s)	(m0.67/s2)	
2.22677	44.78	58.05	20.0	0.00887	0.0	0.0	0.113	4.53E-4	
2.23005	44.71	59.86	30.0	0.0335	0.0	0.0	0.113	4.53E-4	
2.23105	44.69	61.61	40.0	0.0581	0.0	0.0	0.113	4.53E-4	
2.2312	44.69	63.32	50.0	0.0827	0.0	0.0	0.113	4.53E-4	
2.22958	44.72	64.98	60.0	0.107	0.0	0.0	0.113	4.53E-4	
2.22497	44.81	66.6	70.0	0.132	0.0	0.0	0.113	4.53E-4	
2.21666	44.98	68.19	80.0	0.157	0.0	0.0	0.113	4.53E-4	
2.20516	**45.22**	**69.73**	**90.0**	0.181	0.0	0.0	0.113	4.53E-4	
2.19075	**45.51**	**71.24**	**100.0**	0.206	0.0	0.0	0.113	4.53E-4	**chronic (98 m)**

/ Windows UM3. 10/18/2001 8:05:47 AM
Case 6; ambient file C:\Plumes\agr6.001.db; Diffuser table record 1: ----------
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P-dia (m)	P-elev (m)	V-angle (deg)	H-angle (deg)	Ports ()	Spacing (m)	AcuteMZ (m)	ChrncMZ (m)	P-depth (m)	Ttl-flo (m3/s)	Eff-sal (psu)	Temp (C)	Polutnt (%)
0.1524	0.4572	0.0	105.0	44.0	1.219	9.78	97.8	6.401	1.226	0.0	32.2	100.0

Froude number: 22.72

Step	Depth (m)	Amb-cur (m/s)	Amb-tem (C)	P-dia (m)	Polutnt (%)	Dilutn ()	CL-diln ()	x-posn (m)	y-posn (m)	
0	6.401	0.457	21.1	0.152	100.0	1.0	1.0	0.0	0.0;	
10	6.401	0.457	21.1	0.179	82.03	1.218	1.0	-0.0167	0.0646;	
20	6.401	0.457	21.1	0.211	67.3	1.484	1.0	-0.0341	0.137;	
30	6.401	0.457	21.1	0.247	55.21	1.809	1.0	-0.0529	0.221;	
40	6.4	0.457	21.1	0.288	45.29	2.204	1.0	-0.0731	0.321;	
50	6.4	0.457	21.1	0.334	37.15	2.686	1.021	-0.0949	0.439;	
60	6.399	0.457	21.1	0.385	30.48	3.274	1.201	-0.118	0.581;	
70	6.398	0.457	21.1	0.442	25.0	3.99	1.413	-0.143	0.752;	
80	6.396	0.457	21.1	0.506	20.51	4.863	1.663	-0.171	0.962;	
90	6.393	0.457	21.1	0.575	16.83	5.928	1.961	-0.2	1.221;	
100	6.39	0.457	21.1	0.652	13.8	7.225	2.316	-0.231	1.545;	
110	6.384	0.457	21.1	0.736	11.32	8.807	2.741	-0.266	1.956;	
120	6.376	0.457	21.1	0.829	9.289	10.74	3.254	-0.303	2.48;	
130	6.365	0.457	21.1	0.93	7.62	13.09	3.873	-0.344	3.157;	
138	6.352	0.457	21.1	1.018	6.504	15.33	4.461	-0.38	3.836;	bottom hit,
140	6.349	0.457	21.1	1.041	6.251	15.95	4.622	-0.389	4.028;	
150	6.326	0.457	21.1	1.162	5.128	19.44	5.532	-0.436	5.127;	
153	6.317	0.457	21.1	1.201	4.833	20.63	5.865	-0.451	5.506;	merging,
160	6.27	0.457	21.1	1.314	4.207	23.7	6.939	-0.516	7.383;	
168	6.19	0.457	21.1	1.483	3.591	**27.77**	**8.57**	**-0.597**	**10.01;**	**acute,**
170	6.167	0.457	21.1	1.531	3.451	28.89	9.067	-0.616	10.7;	
180	6.029	0.457	21.1	1.816	2.831	35.22	12.34	-0.71	14.45;	
190	5.851	0.457	21.1	2.177	2.323	42.93	17.84	-0.8	18.77;	
200	5.629	0.457	21.1	2.63	1.905	52.33	24.11	-0.886	23.81;	
210	5.351	0.457	21.1	3.191	1.563	63.79	29.28	-0.971	29.77;	
220	5.008	0.457	21.1	3.883	1.282	77.76	35.58	-1.055	36.87;	
230	4.585	0.457	21.1	4.734	1.052	94.78	43.26	-1.137	45.4;	
240	4.065	0.457	21.1	5.775	0.863	115.5	52.62	-1.219	55.67;	
250	3.426	0.457	21.1	7.049	0.708	140.8	64.02	-1.301	68.1;	surface,

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 57.68 m

conc (%)	dilutn	width (m)	distnce (m)	time (hrs)	(%)	(s-1)	(m/s)	(m0.67/s2)	
0.70465	141.5	57.77	70.0	0.00115	0.0	0.0	0.457	4.53E-4	
0.70591	141.2	58.22	80.0	0.00723	0.0	0.0	0.457	4.53E-4	
0.70645	**141.1**	**58.68**	**90.0**	0.0133	0.0	0.0	0.457	4.53E-4	**chronic (98 m)**

/ Windows UM3. 10/18/2001 8:09:45 AM
Case 7; ambient file C:\Plumes\agr7.001.db; Diffuser table record 1: ----------
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P-dia	P-elev	V-angle	H-angle	Ports	Spacing	AcuteMZ	ChrncMZ	P-depth	Ttl-flo	Eff-sal	Temp	Polutnt
(m)	(m)	(deg)	(deg)	()	(m)	(m)	(m)	(m)	(m3/s)	(psu)	(C)	(%)
0.1524	0.4572	0.0	105.0	44.0	1.219	9.78	97.8	6.401	1.226	0.0	32.2	100.0

Froude number: 20.42

Step	Depth (m)	Amb-cur (m/s)	Amb-tem (C)	P-dia (m)	Polutnt (%)	Dilutn ()	CL-diln ()	x-posn (m)	y-posn (m)	
0	6.401	1.128	17.5	0.152	100.0	1.0	1.0	0.0	0.0;	
10	6.401	1.128	17.5	0.172	82.03	1.218	1.0	-0.0137	0.0553;	
20	6.401	1.128	17.5	0.194	67.3	1.484	1.0	-0.0266	0.117;	
30	6.401	1.128	17.5	0.219	55.21	1.808	1.0	-0.0406	0.196;	
40	6.401	1.128	17.5	0.245	45.29	2.203	1.0	-0.0559	0.297;	
50	6.4	1.128	17.5	0.274	37.15	2.685	1.0	-0.0726	0.429;	
60	6.4	1.128	17.5	0.306	30.48	3.272	1.0	-0.0909	0.603;	
70	6.399	1.128	17.5	0.34	25.0	3.988	1.107	-0.111	0.831;	
80	6.397	1.128	17.5	0.379	20.51	4.86	1.331	-0.133	1.134;	
90	6.395	1.128	17.5	0.42	16.83	5.924	1.604	-0.158	1.535;	
100	6.392	1.128	17.5	0.466	13.8	7.22	1.938	-0.184	2.068;	
110	6.388	1.128	17.5	0.517	11.32	8.801	2.344	-0.214	2.769;	
120	6.382	1.128	17.5	0.572	9.289	10.73	2.84	-0.245	3.682;	
130	6.373	1.128	17.5	0.634	7.62	13.08	3.444	-0.278	4.857;	
140	6.362	1.128	17.5	0.701	6.251	15.94	4.18	-0.314	6.357;	
150	6.346	1.128	17.5	0.775	5.128	19.43	5.077	-0.35	8.25;	
157	6.332	1.128	17.5	0.832	4.465	**22.32**	**5.82**	**-0.376**	**9.849;acute**	
160	6.325	1.128	17.5	0.857	4.207	23.68	6.171	-0.387	10.61;	
170	6.298	1.128	17.5	0.948	3.451	28.87	7.505	-0.425	13.52;	
180	6.263	1.128	17.5	1.047	2.831	35.19	9.131	-0.464	17.08;	
190	6.22	1.128	17.5	1.157	2.323	42.9	11.11	-0.502	21.38;	
192	6.21	1.128	17.5	1.181	2.232	44.63	11.56	-0.509	22.34;	merging,
200	6.136	1.128	17.5	1.295	1.905	52.29	14.12	-0.557	29.17;	
210	6.017	1.128	17.5	1.49	1.563	63.74	18.57	-0.616	39.07;	
220	5.872	1.128	17.5	1.744	1.282	77.7	25.24	-0.672	50.36;	
230	5.694	1.128	17.5	2.067	1.052	94.72	36.06	-0.725	63.57;	
240	5.477	1.128	17.5	2.471	0.863	115.5	52.04	-0.776	79.27;	
250	5.212	1.128	17.5	2.972	0.708	**140.7**	**63.42**	**-0.827**	**98.09;chronic**	
260	4.888	1.128	17.5	3.591	0.581	171.6	77.29	-0.878	120.8;	
270	4.493	1.128	17.5	4.351	0.476	209.1	94.2	-0.928	148.3;	
280	4.012	1.128	17.5	5.282	0.391	254.9	114.8	-0.977	181.6;	
290	3.424	1.128	17.5	6.422	0.321	310.8	139.9	-1.027	222.2;	

/ Windows UM3. 11/06/2001 3:22:08 PM
Case 1; ambient file C:\Plumes**agr7b.001.db**; Diffuser table record 1: ----------
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P-dia	P-elev	V-angle	H-angle	Ports	Spacing	AcuteMZ	ChrncMZ	P-depth	Ttl-flo	Eff-sal	Temp	Polutnt
(m)	(m)	(deg)	(deg)	()	(m)	(m)	(m)	(m)	(m3/s)	(psu)	(C)	(%)
0.1524	0.4572	0.0	105.0	44.0	1.219	9.78	97.8	6.401	1.226	0.0	32.2	100.0

Froude number: 22.72

Step	Amb-cur (m/s)	Amb-tem (C)	P-dia (m)	Polutnt (%)	Dilutn ()	x-posn (m)	y-posn (m)	Time (s)	
0	1.128	21.1	0.152	100.0	1.0	0.0	0.0	0.0;	
10	1.128	21.1	0.172	82.03	1.218	-0.0137	0.0553	0.0384;	
20	1.128	21.1	0.194	67.3	1.484	-0.0266	0.117	0.0829;	
30	1.128	21.1	0.219	55.21	1.809	-0.0406	0.196	0.142;	
40	1.128	21.1	0.245	45.29	2.204	-0.0559	0.297	0.22;	
50	1.128	21.1	0.274	37.15	2.686	-0.0726	0.43	0.324;	
60	1.128	21.1	0.306	30.48	3.274	-0.0909	0.603	0.464;	
70	1.128	21.1	0.341	25.0	3.99	-0.111	0.832	0.651;	
80	1.128	21.1	0.379	20.51	4.863	-0.133	1.134	0.902;	
90	1.128	21.1	0.42	16.83	5.928	-0.158	1.536	1.239;	
100	1.128	21.1	0.466	13.8	7.225	-0.185	2.07	1.691;	
110	1.128	21.1	0.517	11.32	8.807	-0.214	2.777	2.295;	
120	1.128	21.1	0.573	9.289	10.74	-0.246	3.7	3.089;	
130	1.128	21.1	0.634	7.62	13.09	-0.28	4.896	4.122;	
140	1.128	21.1	0.701	6.251	15.95	-0.316	6.427	5.452;	
150	1.128	21.1	0.776	5.128	19.44	-0.353	8.366	7.142;	
157	1.128	21.1	0.832	4.465	**22.33**	-0.38	10.01	8.578;	**acute zone,**
160	1.128	21.1	0.858	4.207	23.7	-0.391	10.79	9.264;	
170	1.128	21.1	0.948	3.451	28.89	-0.431	13.8	11.9;	
180	1.128	21.1	1.048	2.831	35.22	-0.47	17.48	15.13;	
190	1.128	21.1	1.158	2.323	42.93	-0.51	21.94	19.06;	
192	1.128	21.1	1.181	2.232	44.66	-0.517	22.94	19.93;	merging,
200	1.128	21.1	1.296	1.905	52.33	-0.569	30.18	26.32;	
210	1.128	21.1	1.491	1.563	63.79	-0.631	40.66	35.55;	
220	1.128	21.1	1.745	1.282	77.76	-0.689	52.54	46.04;	
230	1.128	21.1	2.068	1.052	94.78	-0.745	66.41	58.3;	
240	1.128	21.1	2.473	0.863	115.5	-0.799	82.87	72.85;	
248	1.128	21.1	2.865	0.736	135.4	-0.842	98.35	86.53;	**chronic zone,**
250	1.128	21.1	2.974	0.708	140.8	-0.852	102.6	90.28;	
260	1.128	21.1	3.593	0.581	171.7	-0.905	126.3	111.3;	
270	1.128	21.1	4.354	0.476	209.3	-0.957	155.1	136.8;	
280	1.128	21.1	5.286	0.391	255.1	-1.009	190.0	167.6;	
290	1.128	21.1	6.426	0.321	311.0	-1.061	232.3	205.1;	
292	1.128	21.1	6.683	0.308	323.6	-1.072	241.9	213.6;	surface,

Outside chronic zone

/ Windows UM3. 10/18/2001 8:17:28 AM
Case 8; ambient file C:\Plumes\agr8.001.db; Diffuser table record 1: ----------
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P-dia (m)	P-elev (m)	V-angle (deg)	H-angle (deg)	Ports ()	Spacing (m)	AcuteMZ (m)	ChrncMZ (m)	P-depth (m)	Ttl-flo (m3/s)	Eff-sal (psu)	Temp (C)	Polutnt (%)
0.1524	0.4572	0.0	105.0	44.0	1.219	9.78	97.8	6.401	1.752	0.0	32.2	100.0

Froude number: 32.47

Step	Depth (m)	Amb-cur (m/s)	Amb-tem (C)	P-dia (m)	Polutnt (%)	Dilutn ()	CL-diln ()	x-posn (m)	y-posn (m)	
0	6.401	0.113	21.1	0.152	100.0	1.0	1.0	0.0	0.0;	
10	6.401	0.113	21.1	0.183	82.03	1.218	1.0	-0.0203	0.0763;	
20	6.401	0.113	21.1	0.222	67.3	1.484	1.0	-0.0443	0.168;	
30	6.401	0.113	21.1	0.268	55.21	1.809	1.0	-0.0726	0.277;	
40	6.4	0.113	21.1	0.324	45.29	2.204	1.084	-0.106	0.408;	
50	6.4	0.113	21.1	0.39	37.15	2.686	1.307	-0.145	0.564;	
60	6.398	0.113	21.1	0.469	30.48	3.274	1.573	-0.19	0.75;	
70	6.396	0.113	21.1	0.563	25.0	3.99	1.889	-0.241	0.971;	
80	6.393	0.113	21.1	0.674	20.51	4.863	2.263	-0.3	1.231;	
90	6.387	0.113	21.1	0.803	16.83	5.928	2.704	-0.367	1.539;	
100	6.378	0.113	21.1	0.955	13.8	7.225	3.223	-0.441	1.901;	
101	6.377	0.113	21.1	0.971	13.53	7.37	3.28	-0.449	1.94;	bottom hit,
110	6.365	0.113	21.1	1.13	11.32	8.807	3.832	-0.524	2.326;	
115	6.355	0.113	21.1	1.227	10.26	9.723	4.187	-0.568	2.566;	merging,
120	6.337	0.113	21.1	1.351	9.289	10.74	4.705	-0.641	2.974;	
130	6.26	0.113	21.1	1.706	7.62	13.09	6.16	-0.844	4.184;	
140	6.091	0.113	21.1	2.214	6.251	15.95	8.649	-1.115	5.935;	
150	5.767	0.113	21.1	2.9	5.128	19.44	11.18	-1.439	8.235;	
156	5.487	0.113	21.1	3.411	4.554	**21.9**	**12.46**	**-1.641**	**9.791;**	**acute**
160	5.263	0.113	21.1	3.798	4.207	23.7	13.4	-1.775	10.88;	
170	4.568	0.113	21.1	4.95	3.451	28.89	16.08	-2.105	13.8;	
180	3.661	0.113	21.1	6.408	2.831	35.22	19.34	-2.425	17.0;	
184	3.231	0.113	21.1	7.09	2.616	38.12	20.83	-2.551	18.38;	surface,

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 57.72 m

conc (%)	dilutn	width (m)	distnce (m)	time (hrs)	(%)	(s-1)	(m/s)	(m0.67/s2)	
2.60602	38.26	57.99	20.0	0.00356	0.0	0.0	0.113	4.53E-4	
2.61243	38.17	59.82	30.0	0.0282	0.0	0.0	0.113	4.53E-4	
2.61385	38.14	61.59	40.0	0.0528	0.0	0.0	0.113	4.53E-4	
2.6143	38.14	63.31	50.0	0.0774	0.0	0.0	0.113	4.53E-4	
2.61302	38.16	64.98	60.0	0.102	0.0	0.0	0.113	4.53E-4	
2.60855	38.22	66.62	70.0	0.127	0.0	0.0	0.113	4.53E-4	
2.59982	38.35	68.21	80.0	0.151	0.0	0.0	0.113	4.53E-4	
2.58732	**38.54**	**69.77**	**90.0**	0.176	0.0	0.0	0.113	4.53E-4	
2.5713	**38.78**	**71.29**	**100.0**	0.201	0.0	0.0	0.113	4.53E-4	**chronic (98 m)**

/ Windows UM3. 10/18/2001 8:42:54 AM
Case 9; ambient file C:\Plumes\agr9.001.db; Diffuser table record 1: ----------
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P-dia	P-elev	V-angle	H-angle	Ports	Spacing	AcuteMZ	ChrncMZ	P-depth	Ttl-flo	Eff-sal	Temp	Polutnt
(m)	(m)	(deg)	(deg)	()	(m)	(m)	(m)	(m)	(m3/s)	(psu)	(C)	(%)
0.1524	0.4572	0.0	105.0	44.0	1.219	9.78	97.8	6.401	1.752	0.0	32.2	100.0

Froude number: 29.18

Step	Depth (m)	Amb-cur (m/s)	Amb-tem (C)	P-dia (m)	Polutnt (%)	Dilutn ()	CL-diln ()	x-posn (m)	y-posn (m)	
0	6.401	1.128	17.5	0.152	100.0	1.0	1.0	0.0	0.0;	
10	6.401	1.128	17.5	0.175	82.03	1.218	1.0	-0.0148	0.0583;	
20	6.401	1.128	17.5	0.202	67.3	1.484	1.0	-0.029	0.122;	
30	6.401	1.128	17.5	0.232	55.21	1.808	1.0	-0.0443	0.199;	
40	6.401	1.128	17.5	0.264	45.29	2.203	1.0	-0.0607	0.294;	
50	6.401	1.128	17.5	0.3	37.15	2.685	1.0	-0.0783	0.411;	
60	6.4	1.128	17.5	0.339	30.48	3.272	1.031	-0.0974	0.559;	
70	6.4	1.128	17.5	0.382	25.0	3.988	1.221	-0.118	0.746;	
80	6.399	1.128	17.5	0.429	20.51	4.86	1.451	-0.141	0.987;	
90	6.398	1.128	17.5	0.481	16.83	5.924	1.729	-0.165	1.298;	
100	6.397	1.128	17.5	0.537	13.8	7.22	2.066	-0.192	1.704;	
110	6.394	1.128	17.5	0.599	11.32	8.801	2.475	-0.222	2.235;	
120	6.391	1.128	17.5	0.667	9.289	10.73	2.973	-0.255	2.935;	
130	6.386	1.128	17.5	0.742	7.62	13.08	3.58	-0.29	3.861;	
140	6.38	1.128	17.5	0.824	6.251	15.94	4.318	-0.33	5.09;	
150	6.37	1.128	17.5	0.914	5.128	19.43	5.217	-0.373	6.712;	
159	6.357	1.128	17.5	1.003	4.291	23.22	6.192	-0.415	8.58;	bottom hit,
160	6.355	1.128	17.5	1.013	4.207	23.68	6.312	-0.42	8.814;	
164	6.348	1.128	17.5	1.055	3.887	**25.64**	**6.814**	**-0.439**	**9.813; acute**	
170	6.336	1.128	17.5	1.122	3.451	28.87	7.647	-0.469	11.5;	
176	6.321	1.128	17.5	1.193	3.065	32.51	8.616	-0.499	13.44;	merging,
180	6.297	1.128	17.5	1.248	2.831	35.19	9.5	-0.539	16.22;	
190	6.203	1.128	17.5	1.43	2.323	42.9	12.36	-0.652	25.28;	
200	6.078	1.128	17.5	1.67	1.905	52.29	16.6	-0.754	35.24;	
210	5.921	1.128	17.5	1.978	1.563	63.74	23.32	-0.849	46.56;	
220	5.724	1.128	17.5	2.364	1.282	77.7	35.19	-0.94	59.74;	
230	5.481	1.128	17.5	2.844	1.052	94.72	42.84	-1.029	75.34;	
240	5.182	1.128	17.5	3.437	0.863	115.5	52.18	-1.116	93.98;	
242	5.114	1.128	17.5	3.571	0.829	**120.1**	**54.28**	**-1.134**	**98.13;chronic**	
250	4.814	1.128	17.5	4.167	0.708	140.7	63.56	-1.202	116.4;	
260	4.363	1.128	17.5	5.061	0.581	171.6	77.43	-1.288	143.5;	
270	3.81	1.128	17.5	6.157	0.476	209.1	94.34	-1.373	176.3;	

/ Windows UM3. 11/06/2001 3:24:44 PM
Case 1; ambient file C:\Plumes**agr9b.001.db**; Diffuser table record 1: ----------
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P-dia	P-elev	V-angle	H-angle	Ports	Spacing	AcuteMZ	ChrncMZ	P-depth	Ttl-flo	Eff-sal	Temp	Polutnt
(m)	(m)	(deg)	(deg)	()	(m)	(m)	(m)	(m)	(m3/s)	(psu)	(C)	(%)
0.1524	0.4572	0.0	105.0	44.0	1.219	9.78	97.8	6.401	1.7525	0.0	32.2	100.0

Froude number: 32.48

Step	Depth (m)	Amb-cur (m/s)	Amb-tem (C)	P-dia (m)	Polutnt (%)	Dilutn ()	x-posn (m)	y-posn (m)	Time (s)	
0	6.401	1.128	21.1	0.152	100.0	1.0	0.0	0.0	0.0;	
10	6.401	1.128	21.1	0.176	82.03	1.218	-0.0148	0.0583	0.029;	
20	6.401	1.128	21.1	0.202	67.3	1.484	-0.0291	0.122	0.0635;	
30	6.401	1.128	21.1	0.232	55.21	1.809	-0.0443	0.199	0.108;	
40	6.401	1.128	21.1	0.264	45.29	2.204	-0.0607	0.294	0.167;	
50	6.401	1.128	21.1	0.3	37.15	2.686	-0.0783	0.411	0.244;	
60	6.4	1.128	21.1	0.339	30.48	3.274	-0.0974	0.559	0.346;	
70	6.4	1.128	21.1	0.382	25.0	3.99	-0.118	0.747	0.48;	
80	6.399	1.128	21.1	0.429	20.51	4.863	-0.141	0.987	0.659;	
90	6.398	1.128	21.1	0.481	16.83	5.928	-0.165	1.298	0.897;	
100	6.397	1.128	21.1	0.537	13.8	7.225	-0.192	1.704	1.215;	
110	6.395	1.128	21.1	0.599	11.32	8.807	-0.222	2.236	1.64;	
120	6.392	1.128	21.1	0.667	9.289	10.74	-0.255	2.936	2.211;	
130	6.388	1.128	21.1	0.742	7.62	13.09	-0.291	3.862	2.977;	
140	6.382	1.128	21.1	0.824	6.251	15.95	-0.33	5.091	4.005;	
150	6.373	1.128	21.1	0.914	5.128	19.44	-0.374	6.721	5.383;	
158	6.363	1.128	21.1	0.993	4.377	22.78	-0.411	8.379	6.796;	bottom hit,
160	6.36	1.128	21.1	1.013	4.207	23.7	-0.421	8.85	7.198;	
164	6.354	1.128	21.1	1.056	3.887	**25.65**	-0.44	9.864	8.067;	**acute zone,**
170	6.342	1.128	21.1	1.123	3.451	28.89	-0.471	11.58	9.545;	
176	6.328	1.128	21.1	1.193	3.065	32.54	-0.502	13.57	11.25;	merging,
180	6.305	1.128	21.1	1.249	2.831	35.22	-0.543	16.47	13.76;	
190	6.213	1.128	21.1	1.431	2.323	42.93	-0.662	26.04	22.07;	
200	6.089	1.128	21.1	1.672	1.905	52.33	-0.77	36.53	31.2;	
210	5.933	1.128	21.1	1.979	1.563	63.79	-0.87	48.43	41.59;	
220	5.737	1.128	21.1	2.366	1.282	77.76	-0.966	62.26	53.71;	
230	5.495	1.128	21.1	2.847	1.052	94.78	-1.059	78.61	68.06;	
240	5.196	1.128	21.1	3.44	0.863	115.5	-1.15	98.13	85.22;	**chronic zone**
250	4.829	1.128	21.1	4.171	0.708	140.8	-1.24	121.6	105.9;	
260	4.378	1.128	21.1	5.066	0.581	171.7	-1.33	149.9	130.8;	
270	3.825	1.128	21.1	6.163	0.476	209.3	-1.419	184.2	161.1;	
276	3.436	1.128	21.1	6.934	0.423	235.7	-1.472	208.2	182.3;	surface, Outside chronic zone

/ Windows UM3. 10/18/2001 3:54:04 PM
Case 10; ambient file C:\Plumes\agr10.001.db; Diffuser table record 1: ----------
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P-dia (m)	P-elev (m)	V-angle (deg)	H-angle (deg)	Ports ()	Spacing (m)	AcuteMZ (m)	ChrncMZ (m)	P-depth (m)	Ttl-flo (m3/s)	Eff-sal (psu)	Temp (C)	Polutnt (%)
0.1524	0.4572	0.0	105.0	44.0	1.219	9.78	97.8	6.401	1.752	0.0	32.2	100.0

Froude number: 32.47

Step	Depth (m)	Amb-cur (m/s)	Amb-tem (C)	P-dia (m)	Polutnt (%)	Dilutn ()	CL-diln ()	x-posn (m)	y-posn (m)	
0	6.401	0.457	21.1	0.152	100.0	1.0	1.0	0.0	0.0;	
10	6.401	0.457	21.1	0.18	82.03	1.218	1.0	-0.0178	0.0683;	
20	6.401	0.457	21.1	0.214	67.3	1.484	1.0	-0.0371	0.146;	
30	6.401	0.457	21.1	0.254	55.21	1.809	1.0	-0.0584	0.237;	
40	6.401	0.457	21.1	0.299	45.29	2.204	1.0	-0.0818	0.344;	
50	6.4	0.457	21.1	0.351	37.15	2.686	1.105	-0.107	0.469;	
60	6.4	0.457	21.1	0.41	30.48	3.274	1.304	-0.135	0.617;	
70	6.399	0.457	21.1	0.477	25.0	3.99	1.537	-0.165	0.792;	
80	6.398	0.457	21.1	0.551	20.51	4.863	1.808	-0.197	1.002;	
90	6.396	0.457	21.1	0.634	16.83	5.928	2.128	-0.231	1.254;	
100	6.393	0.457	21.1	0.726	13.8	7.225	2.504	-0.268	1.563;	
110	6.39	0.457	21.1	0.828	11.32	8.807	2.951	-0.308	1.943;	
120	6.385	0.457	21.1	0.94	9.289	10.74	3.483	-0.352	2.417;	
121	6.384	0.457	21.1	0.952	9.107	10.95	3.542	-0.356	2.471;	bottom hit,
130	6.377	0.457	21.1	1.063	7.62	13.09	4.12	-0.399	3.016;	
140	6.366	0.457	21.1	1.198	6.251	15.95	4.89	-0.451	3.778;	merging,
150	6.327	0.457	21.1	1.381	5.128	19.44	6.192	-0.572	5.895;	
160	6.245	0.457	21.1	1.638	4.207	23.7	8.139	-0.726	9.068;	
162	6.223	0.457	21.1	1.698	4.044	**24.66**	**8.644**	**-0.758**	**9.787;**	**acute**
170	6.115	0.457	21.1	1.973	3.451	28.89	11.26	-0.883	12.91;	
180	5.936	0.457	21.1	2.398	2.831	35.22	16.69	-1.037	17.38;	
190	5.7	0.457	21.1	2.929	2.323	42.93	20.18	-1.187	22.59;	
200	5.398	0.457	21.1	3.589	1.905	52.33	24.43	-1.333	28.69;	
210	5.019	0.457	21.1	4.401	1.563	63.79	29.61	-1.476	35.91;	
220	4.546	0.457	21.1	5.398	1.282	77.76	35.92	-1.618	44.51;	
230	3.959	0.457	21.1	6.619	1.052	94.78	43.61	-1.758	54.8;	
235	3.616	0.457	21.1	7.329	0.953	104.6	48.06	-1.828	60.7;	surface

Const Eddy Diffusivity. Farfield dispersion based on wastefield width of 57.96 m

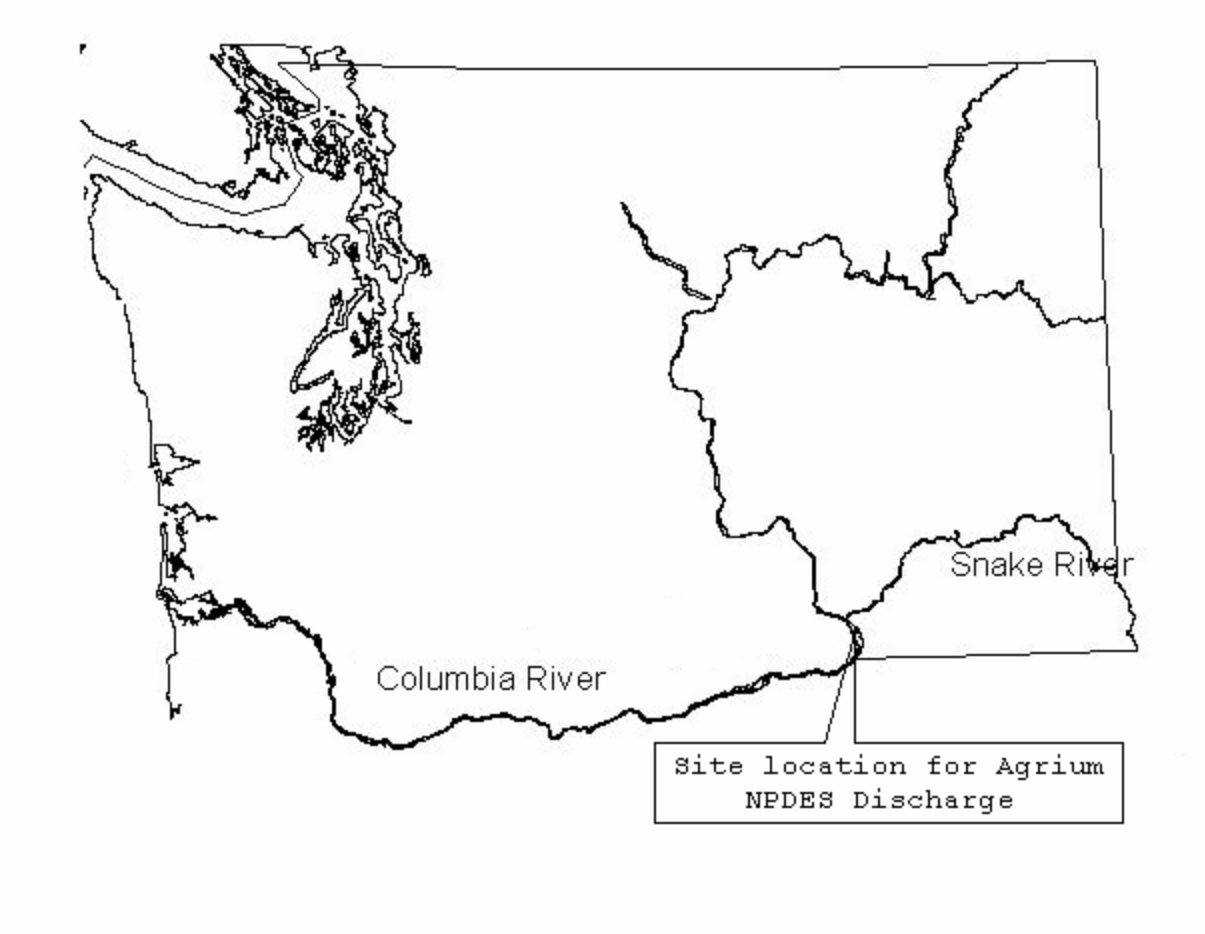
conc (%)	dilutn	width (m)	distnce (m)	time (hrs)	(%)	(s-1)	(m/s)	(m0.67/s2)	
0.94976	105.0	58.38	70.0	0.00564	0.0	0.0	0.457	4.53E-4	
0.95064	104.9	58.84	80.0	0.0117	0.0	0.0	0.457	4.53E-4	
0.9511	**104.8**	**59.29**	**90.0**	0.0178	0.0	0.0	0.457	4.53E-4	
0.9514	**104.8**	**59.74**	**100.0**	0.0239	0.0	0.0	0.457	4.53E-4	**chronic (98 m)**

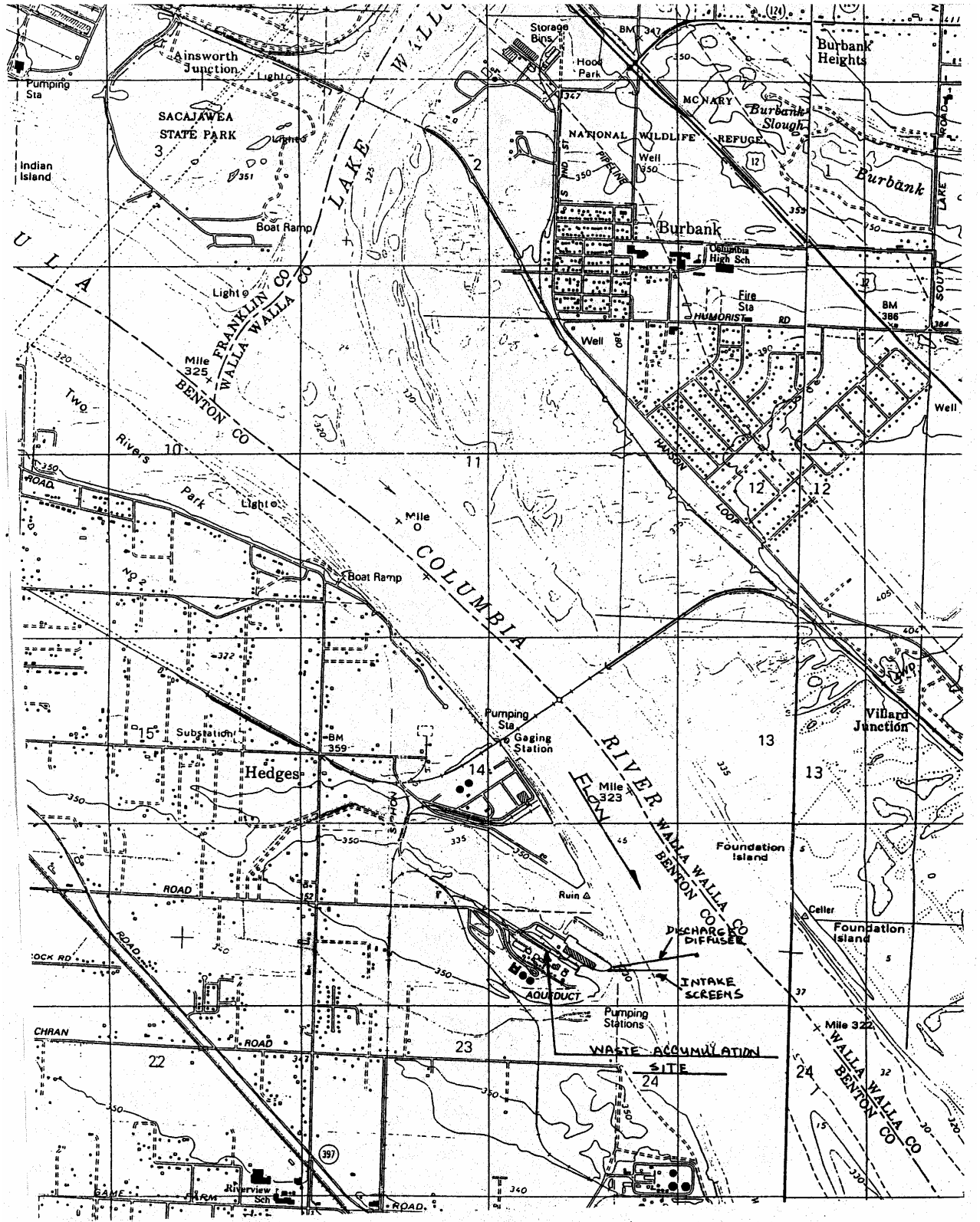
APPENDIX D -- RESPONSE TO FACILITY COMMENTS

The Permittee expressed the desire to have effluent testing frequency be done twice per year instead of more frequently.

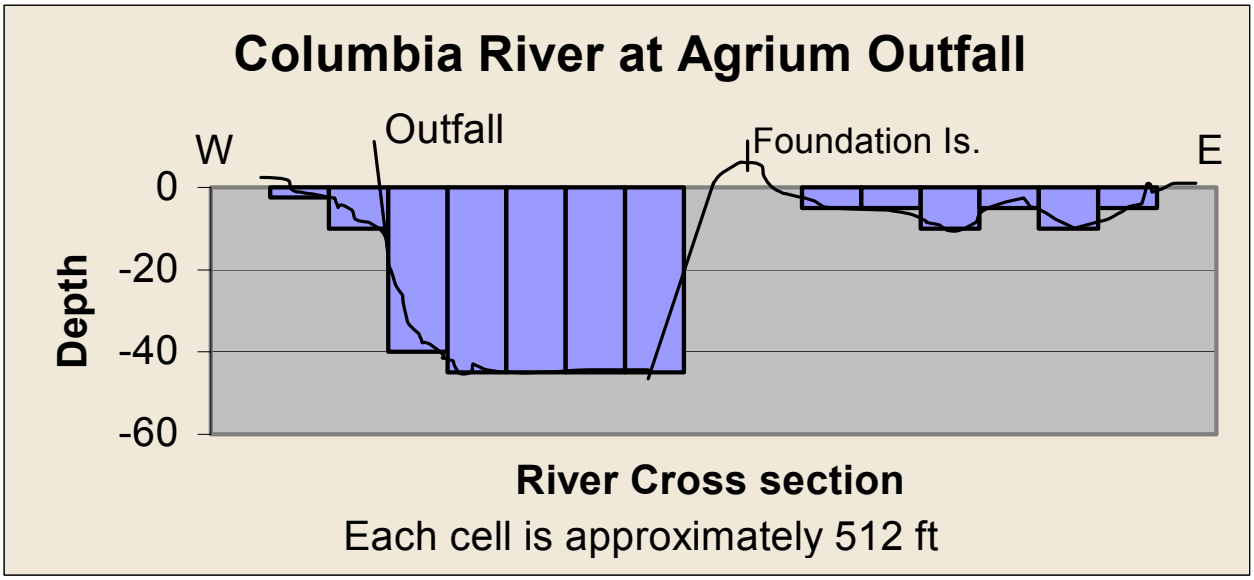
However, Ecology has already shown flexibility in not assigning a chronic WET limit to the discharge. This was based on the past effluent characterization which demonstrated adverse effects to fathead minnows. Past characterizations have had a concentration-response relationship typical of toxicity along with some characteristics that could indicate disease. The new effluent characterization in the draft permit is intended to give Agrium an opportunity to conduct testing to separate effects due to toxicity as opposed to effects due to other causes. If successful in this goal, the new effluent characterization will allow a more accurate determination of the need for an effluent limit for chronic toxicity. In order to be successful, the monitoring frequency needs to be high enough to get a sample which has both types of characteristics in its adverse effects. Quarterly testing is likely the bare minimum frequency with any chance for success. All of these issues were discussed during the meeting in CRO on May 31, 2001 and agreed to by Agrium and their consultant.

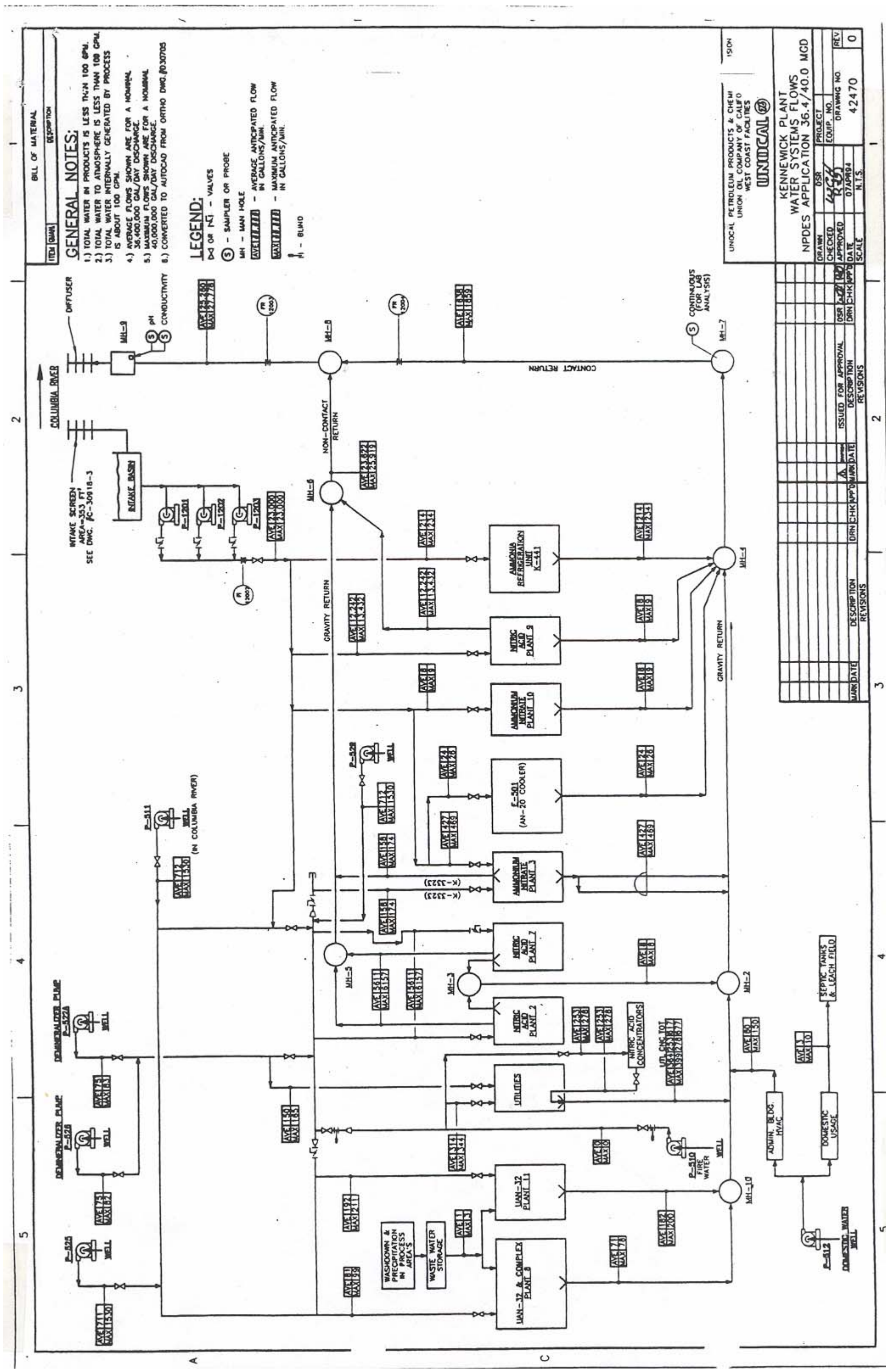
APPENDIX E – MAPS AND GRAPHS

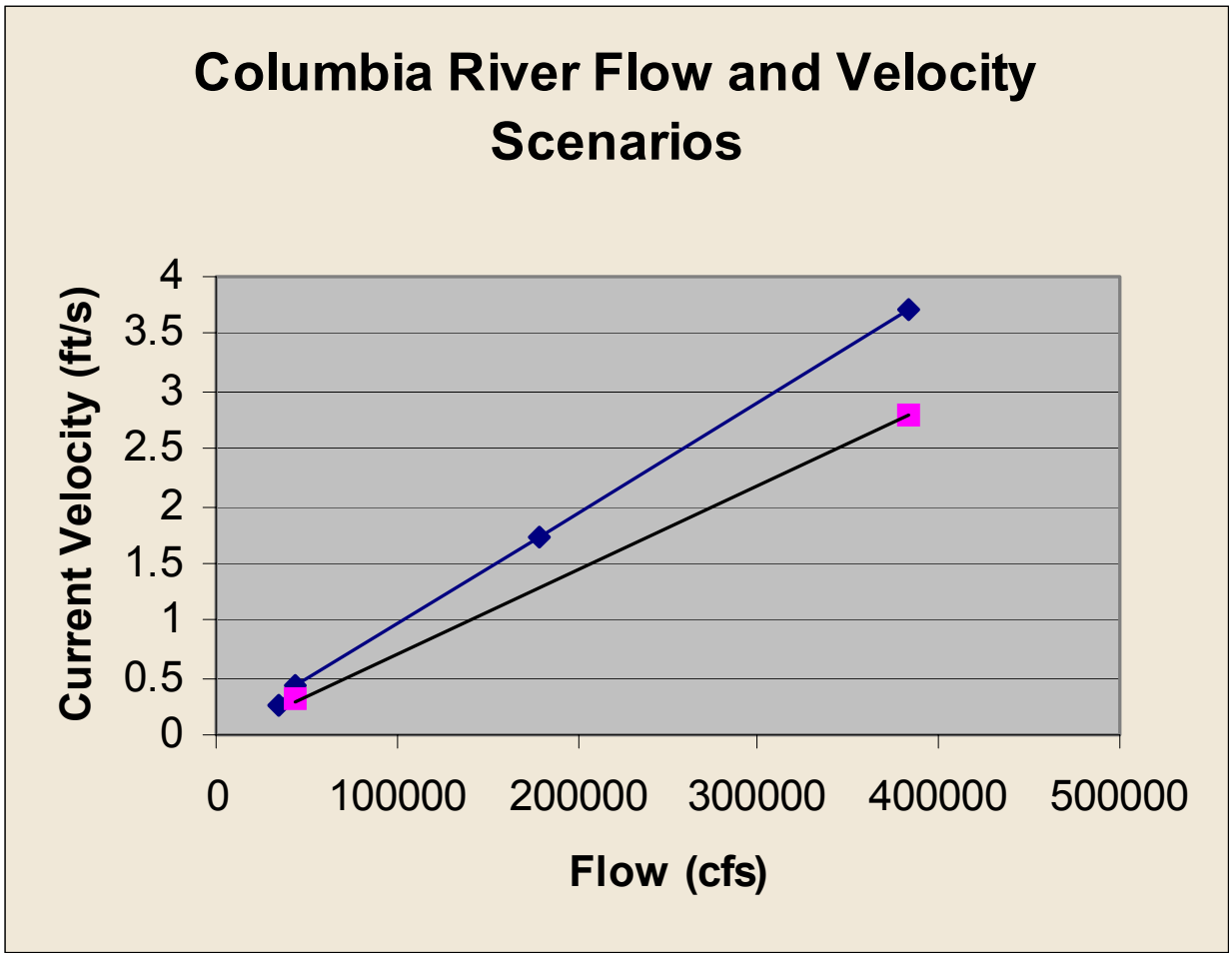




SITE AND OUTFALL LOCATION


Columbia River at Agrium Outfall
W
Outfall
Foundation Is.
E
0
-20
-40
-60
Depth
River Cross section
Each cell is approximately 512 ft


GENERAL NOTES:
LEGEND:
COLUMBIA RIVER
INTAKE BASIN
CONTACT RETURN
NON-CONTACT RETURN
GRAVITY RETURN
UNOCAL PETROLEUM PRODUCTS & CHEMI
UNION OIL COMPANY OF CALIFO
WEST COAST FACILITIES
UNOCAL
KENNEWICK PLANT
WATER SYSTEMS FLOWS
NPDES APPLICATION 36.4/40.0 MCD
42470


Columbia River Flow and Velocity Scenarios
Current Velocity (ft/s)
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100000
200000
300000
400000
500000
Flow (cfs)